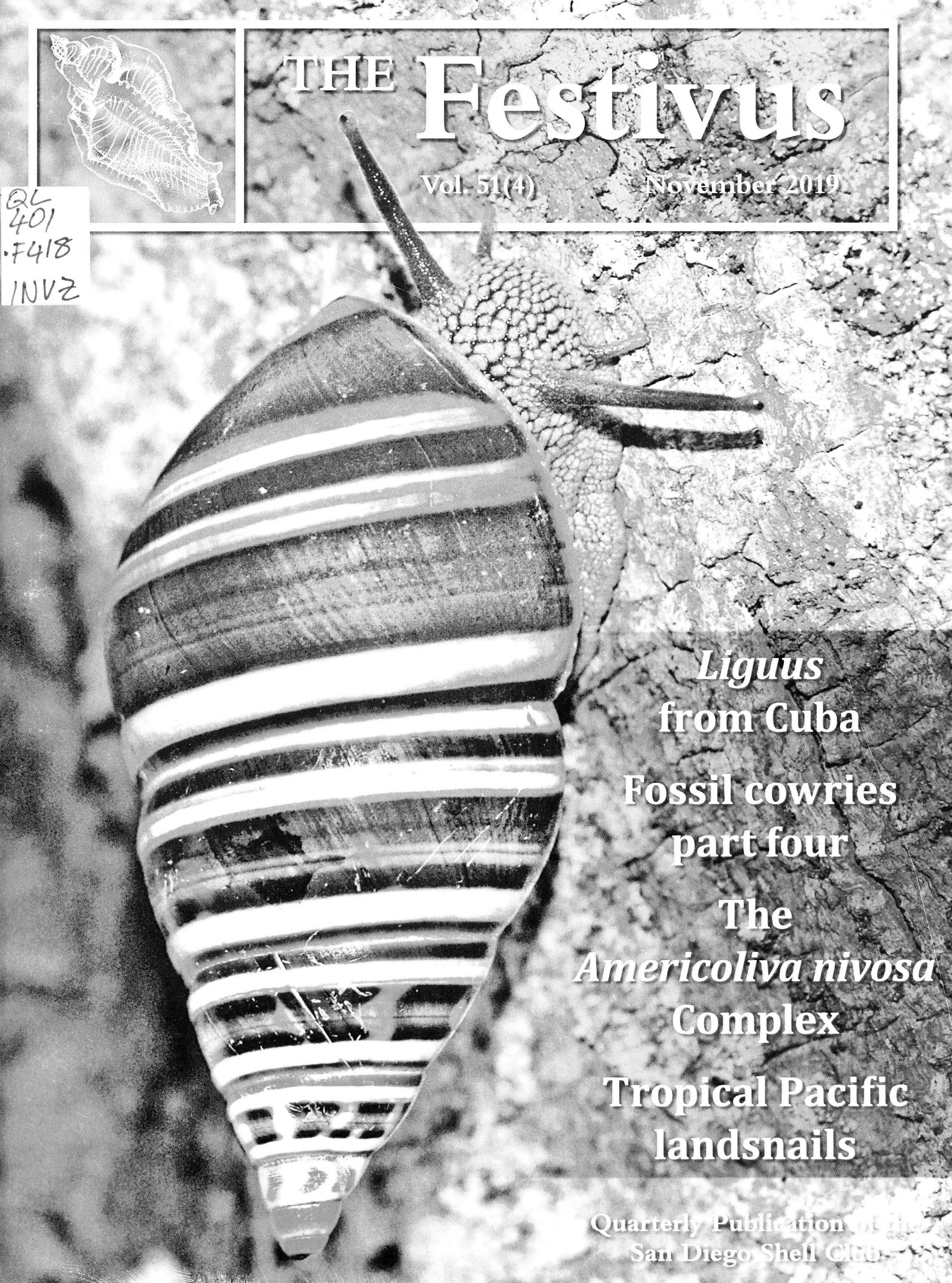


THE Festivus

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November 2019

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Liguus
from Cuba
Fossil cowries
part four

The
Americoliva nivosa
Complex
Tropical Pacific
landsnails

Quarterly Publication of the
San Diego Shell Club



THE FESTIVUS

A publication of the San Diego Shell Club

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November 2019

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Liguus blainianus hybrid photographed by Adrian González-Guillén in Cañón del Río Santa Cruz, San Cristóbal municipality, Pinar del Río province, Cuba. Photo used with permission. All rights reserved. (Cover artistic credit: Rex Stilwill).

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The San Diego Shell Club was founded in 1961 as a non-profit organization for educational and scientific purposes. More particularly to enjoy, study and promote the conservation of Mollusca and associated marine life through lectures, club meetings and field trips. Our membership is diverse and includes beginning collectors, scientists, divers, underwater photographers and dealers.

THE FESTIVUS is the official quarterly publication of the San Diego Shell Club, Inc. and is issued as part of membership dues in February, May, August and November. *The Festivus* publishes articles that are peer reviewed by our volunteer Scientific Peer Review Board, as well as articles of general interest to malacologists, conchologists, and shell collectors of every level. Members of the Peer Review Board are selected to review individual articles based upon their chosen field of expertise and preference. Available by request or on our website are:

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Liguus blainianus, an Endangered Lineage of *Liguus* from the Rosario Range in Western Cuba

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ABSTRACT The *Liguus blainianus* lineage from western Cuba is presented, with a discussion of its placement as a subspecies of *Liguus fasciatus*, current and historical range, distribution maps, comments about past and recent field work and its hybridization with *L. f. archeri*. Color images of live animals and their habitat are included. An argument is made for creating a protected area to avoid the extinction of this beautiful and important race of tree snails.

KEY WORDS *Liguus*, *Liguus blainianus*, tree snails, Cuba

TAXONOMIC HISTORY:

In May of 1853, the Cuban Naturalist Felipe Poey y Aloy (1799-1891) described *Achatina blainiana* in the first volume of his “*Memorias sobre la Historia Natural de la Isla de Cuba*” (1851–1853) [*Memorias No. XV. Especies nuevas de Heliceas. Moluscos terrestres inoperculados*, p. 206-207, Pl. 12, figs. 4-6]. The illustration of the holotype displayed was dated October 1852 in the same volume.

Poey originally collected this beautiful tree snail in the company of the naturalist José León Isidoro Francisco de la Trinidad Blain y Cervantes (1808-?), owner of the “*El Retiro*” farm in Sierra del Rosario in Santa Cruz de los Pinos. Blain’s brother in law, Francisco Adolfo Sauvalle y Chanceaulme (1807-1879), also owned neighboring farms named “*Finca Balestena*” and “*Finca Rangel*”. These farms were the first recorded localities for *L. blainianus* in the 19th century and became mandatory “camping grounds” for naturalists who visited Western Cuba at that time and even years later (ex. Pierre Marie Arthur de Morelet (1809-1892), Charles Wright (1811-1885),

Johann Christoph Gundlach (1810-1896) [González-Guillén, 2019]. Poey collected a “*great quantity*” of specimens noticing the “few or almost no variation among them” (see Poey’s *Memorias*, 1853, at pp. 207 and 361). This prompted him to describe *L. blainianus* as a new species.

Ludwig Pfeiffer (1804-1877), accepted *L. blainianus* as a valid species in several of his publications from 1853 to 1865. Rafael Arango y Molina (1836-1893) did not accept Poey’s species, and in his Cuban Landsnail Catalog of 1865 adamantly declared that *A. blainiana* was a synonym for *A. fasciata* (Müller, 1774). Oddly Poey accepted this assessment without any reluctance (González-Guillén; Krull & Lajonchere, 2018).

In 1899, Pilsbry addressed the genus *Liguus*, recognizing four species including *Liguus blainianus* (Poey, 1853) however, in his discussions he feared giving it full specific rank because: “*there are certain forms of L. fasciatus which approach L. blainianus, and when full series from the region adjacent to its locality are collected, I do not have much doubt that L.*

blainianus will be given subspecific rather than specific rank” (González-Guillén; Krull & Lajonchere, 2018).

When describing *L. blainianus* Poey used only shell characters and no anatomical features to declare it a species. To date, no DNA or other biological studies have been done to prove that *L. blainianus* is not a subspecies of *L. fasciatus*. Further it has been shown that *L. blainianus* hybridizes with *L. f. archeri* where their ranges overlap. Applying traditional definitions of species/subspecies we feel confident to assert herein that *L. blainianus* is a subspecies of *L. fasciatus*.

Even though Poey noted the uniformity of color in most *L. blainianus* shells, some other color forms do exist. In 1935, William Clench described the subspecies *L. blainianus pilsbryi* based on narrower axial flaming and a wider peripheral band [see Pl. n2, figs. 12-20]. We consider this to be a color form. In Pilsbry’s 1899 monograph, another color form is shown with a central creamy band (Pl. 55, fig. 53) which was given the manuscript name *Liguus blainianus mesai* by M.L. Jaume [see Pl. 1, figs. 1-4]. We believe that the last time specimens of this form were collected was in 1981 by Ramón Calzadilla Núñez, but we do not have an exact locality. Jaume also coined the name *L. bl. rangelinus* which remains a manuscript name [see Plate 1, Figure 5].

In the past, other Cuban *Liguus* were included within the *L. blainianus* species including *L. b. guanensis*, *L. b. fairchildi*, *L. b. jaumei*, *L. b. giganteus*, *L. b. minutus*, *L. b. picturatus* and *L. b. guillermi*. Those were shown by A. González-Guillén, F. Krull & L. A. Lajonchere in 2018 to belong to different *Liguus* subspecies [see Plate 3, Figures 1-13]. None of these color forms occur within the *L. blainianus* range.

HISTORICAL AND CURRENT RANGE:

The original range of *Liguus blainianus* covered an area of approximately 40 square miles (100 km²), roughly 5 by 8 miles (see Figures 1 & 2). We have no records of how much of this territory actually supported *Liguus*. Most of this area was probably covered in hardwood forests but by the mid-18th century (or earlier) forest clearing for farming and forest fragmentation had begun, and deforestation continues to this day. Most of the range displayed on the map is no longer covered by primary hardwood forests. In 1960, all the properties that were once the farms of the Blain and Sauvalle families were subdivided “into several farms for crops or cattle raising and all its botanical values were destroyed” (González-García, 2017).



Figure 1. Location of the *Liguus blainianus* distribution area.

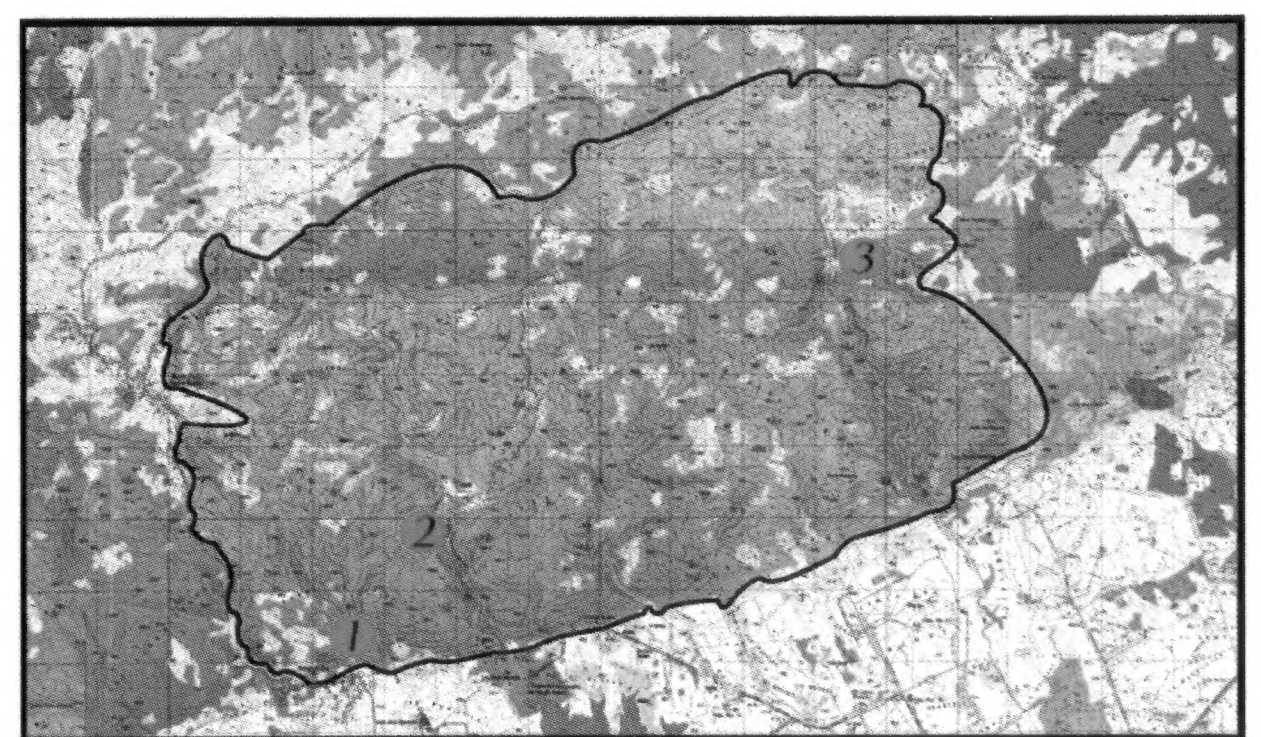


Figure 2. *Liguus blainianus* lineage likely distribution in the 18th-19th centuries, Sierra del Rosario, Guaniguanico mountain range, western Cuba.

Today perhaps less than 50% of primary (semi-deciduous and evergreen type) and secondary forest habitat remains suitable for *Liguus* populations. Of that only about 10% has been recently searched for *Liguus*.

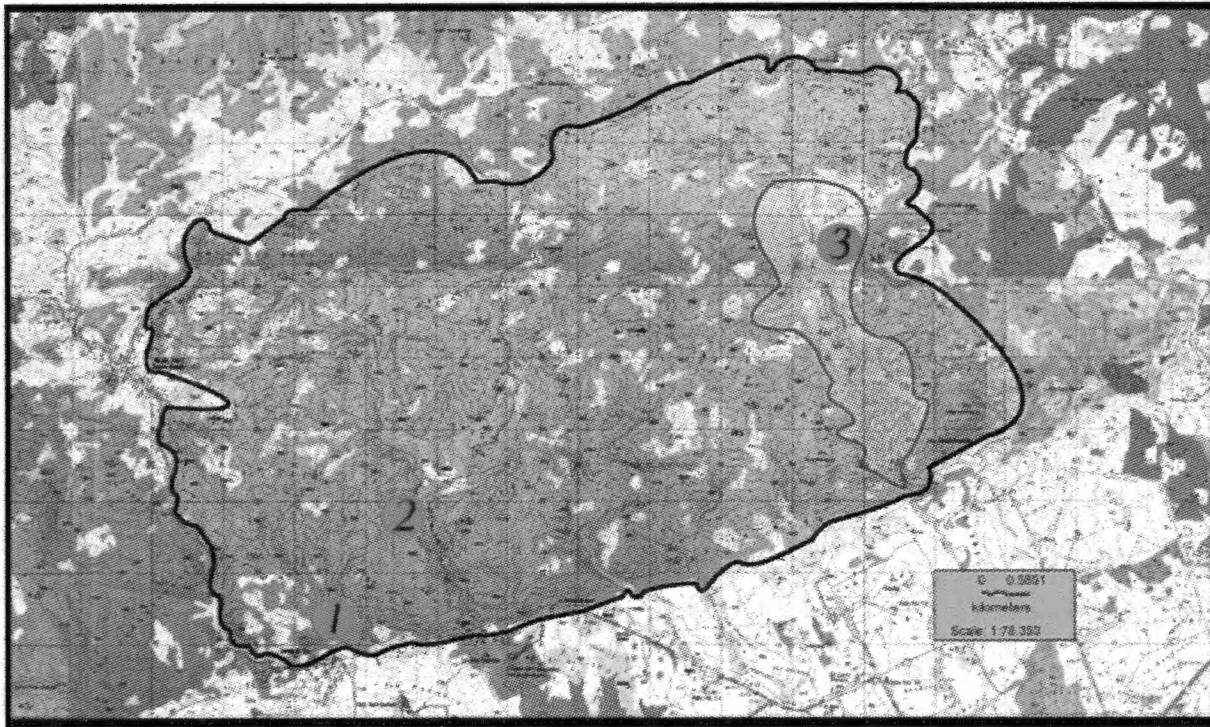


Figure 3. *Liguus blainianus* lineage feasible distribution prior to human settlements in the region, San Cristóbal municipality, Pinar del Río province. Localities visited in 2007 and 2018. Locations noted are: 1 = Campo de Tiro; 2 = Jardines de Aspiro (Aspiro's Gardens); 3 = Cañón del Río Santa Cruz (Santa Cruz River Canyon).

Three remaining *L. blainianus* populations are known: Campo de Tiro from Consejo Popular Fierro, Jardines de Aspiro, and Cañón del Río Santa Cruz, both from Consejo popular Santa Cruz de los Pinos (the latter seemingly containing more hybrid forms than anything). González-Guillén found color forms that have not been described previously during a field trip in 2007, covering the area between El Cañón del Río de Santa Cruz (Santa Cruz River Canyon) and Arroyo del Loro vicinity [see Plate 2, Figures 3 & 9]. These color forms unexpectedly exhibited traits of being hybrids with the *L. fasciatus archeri* lineage [see Plate 3, Figures 14-20]. Periostracal green lines are a good indicator as *L. blainianus* never has green lines, however the presumed hybrids found almost always possess them as well as other "hybrid" color patterns.

Subsequent field trips done by Raimundo L. Silvero and L. A. Lajonchere to the Santa Cruz

River Canyon provided further indication of hybridization [see Plate 3, Figures 4-8, and 10-11]. In 2018, González-Guillén and Lajonchere also successfully found *L. b. pilsbryi* populations in the type locality of Campo de Tiro and found thriving populations of *L. b. blainianus* in Aspiro (see Figure 4).

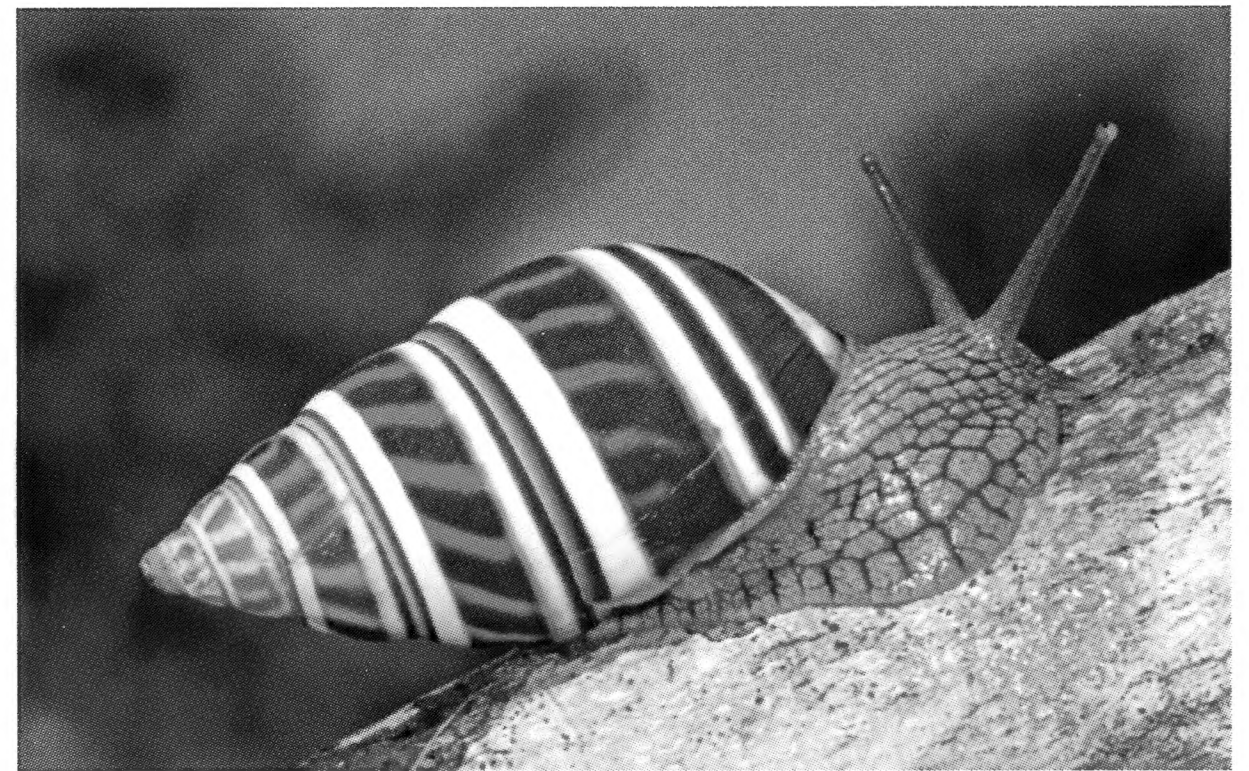


Figure 4. *Liguus blainianus blainianus*, Jardines de Aspiro, San Cristóbal municipality, Pinar del Río province.

The *Liguus* population found in Campo de Tiro seemingly contains higher densities compared with the ones from Aspiro or Santa Cruz River Canyon. In all the populations examined in Campo de Tiro and Aspiro the snails were found aestivating on diverse host plants (frequently in cavities at lower heights) and karstic rock crevices.



Figure 5. *Liguus blainianus pilsbryi*, Campo de Tiro, San Cristóbal municipality, Pinar del Río province.

The colonies were found approximately between 120 to 300 meters above sea level (hereinafter “masl”), but we suspect that they reach higher altitudes surpassing the 500 masl. In the past, Clench and others hypothesized [Laureano Pequeño Sánchez (1890-1962) and Pedro Joaquín Bermúdez (1905-1979)] that *L. b. blainianus* only inhabited the mountain base and that *L. b. pilsbryi* lived at higher elevations. Recent field trips have not proven that hypothesis to be the case.



Figure 6. *Liguus blainianus* hybrid from Cañón del Río Santa Cruz, San Cristóbal municipality, Pinar del Río province.

In Clench's description he indicates that the paratypes of *L. b. pilsbryi* also came from “Sierra de Rangel” and we know from detailed collection records that it also lived west of Rangel in the vicinity of Rancho Mundito (Niceto Pérez). Regrettably, in 2018 efforts to find populations in the Rangel vicinity were

futile. In the past, what was considered as the “Rangel” region covered a large area and no detailed locality records exist of shells that were collected there. It has likewise not been possible to determine the exact whereabouts of old label localities that were recorded as “Rancho Mundito” or “Hoyos del Manantial”.

Note: Consejos Populares (People's Council) is a Cuban government geopolitical subdivision. All localities mentioned here belong to San Cristóbal municipality from the former Pinar del Río province (today's Artemisa province).

DISCUSSION / RECOMMENDATIONS

Much of the *L. blainianus* range remains to be searched for any other remaining snail populations, and a better understanding is needed of their ecology. The area is rugged with tall cliffs and steep valleys and travel is treacherous. While most of the top half of the range has probably been deforested for farming, the lower half likely still contains both primary and secondary forests suitable for *Liguus*.

The establishment of a protected area, probably encompassing the entire original *L. blainianus* range, would be a big step forward in protecting this unique form. Generally, *Liguus* do not become extinct from over-collecting but rather due to the loss of habitat. However, the range of *L. blainianus* is small and it is evident that collecting in the Aspiro area has continued to the present. The establishment of a protected area would dissuade people from collecting these snails there or anywhere within that range.

Finally, further study is needed as to the biology of all *Liguus* forms, together with rigorous mitochondrial and nuclear DNA studies. Although Luis A. Lajonchere is making an effort in that direction as resources become

available, this research has not gained much ground due to lack of funding.

ACKNOWLEDGMENTS

The authors thank Luis Álvarez Lajonchere, Alena Reyes-Fornet, Lori Krull, employees of Campismo Jardín de Aspiro, Tomasito from Santa Cruz de los Pinos, and all the residents who helped in the areas of Aspiro, Campo de Tiro and Rangel, in western Cuba.

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Figure 7. *Liguus blainianus* hybrid. Photo by Raimundo Lopez Silvero.



Figure 8. *Liguus blainianus* hybrid. Photo by Adrian González-Guillén.

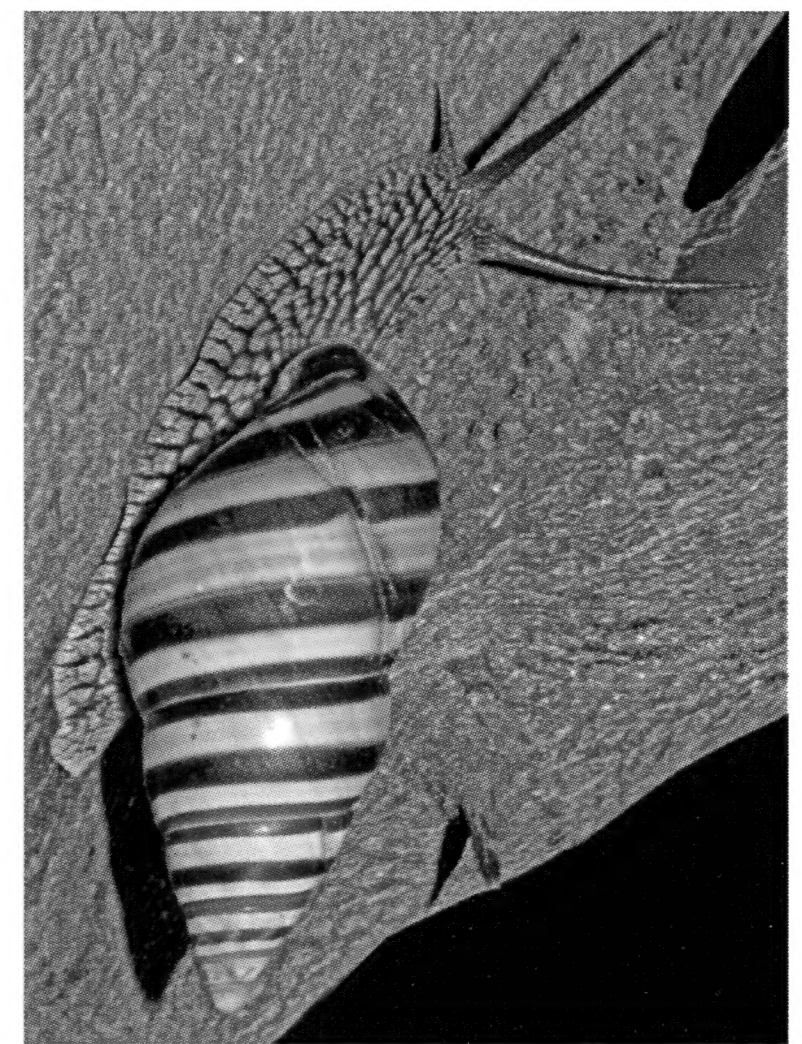


Figure 9. *Liguus blainianus* hybrid. Photo by Luis A. Lajonchere.

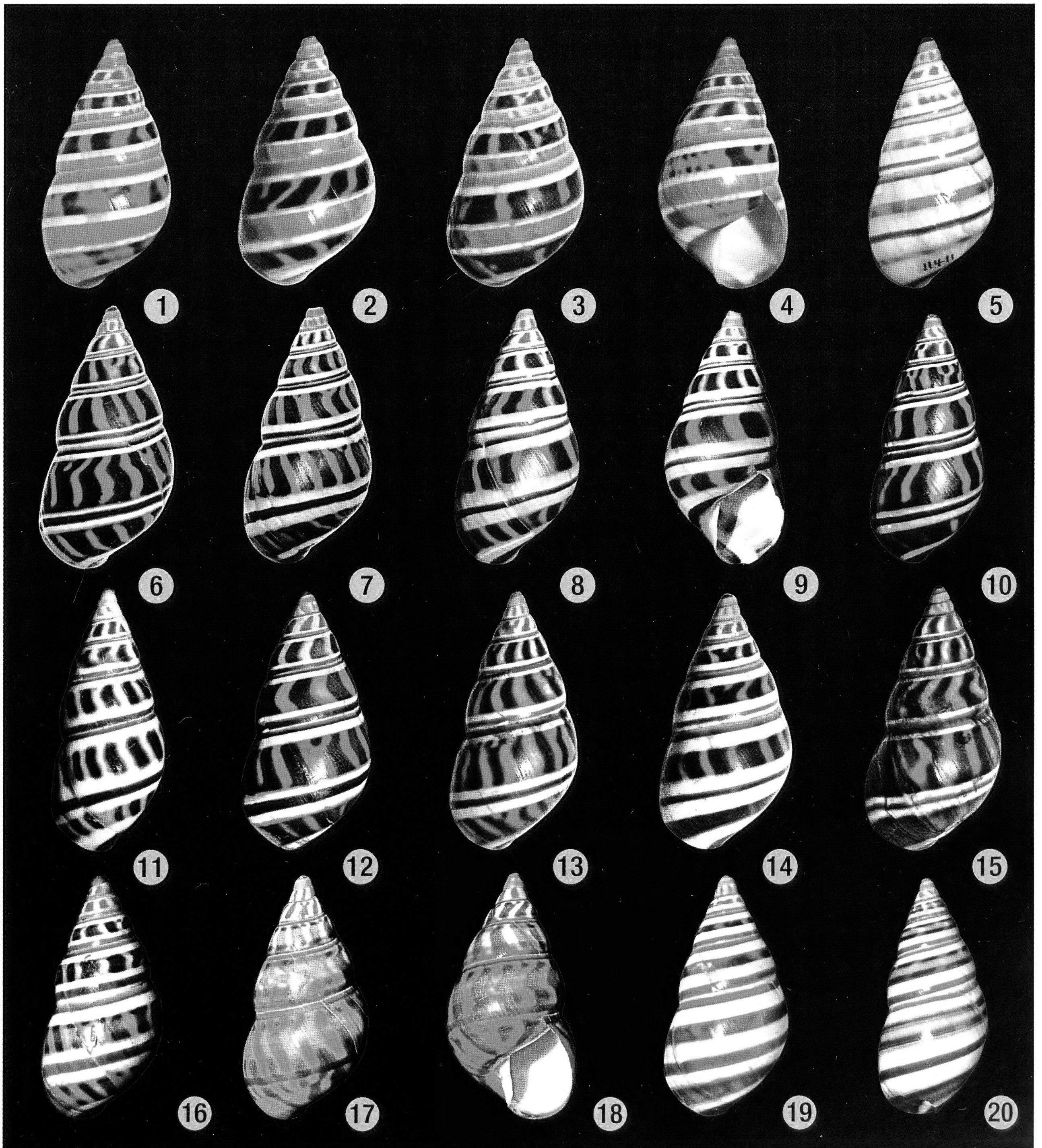


Plate 1. *Liguus blainianus blainianus* specimens. Figures 1-4: *Liguus blainianus blainianus* (manuscript form *mesai* by M.L.Jaume), Aspiro-Rangel-Santa Cruz River Canyon; 5: *Liguus blainianus blainianus* (holotype of manuscript form *rangelinus* by M.L. Jaume), Rangel; 6-12: *Liguus blainianus blainianus*, Aspiro-Taco; 13-15: *Liguus blainianus blainianus*, Campo de Tiro; 16-18: *Liguus blainianus blainianus*, Rangel; 19-20: *Liguus blainianus blainianus*, Santa Cruz River Canyon. All specimens are from the San Cristóbal municipality, Pinar del Río province, western Cuba.

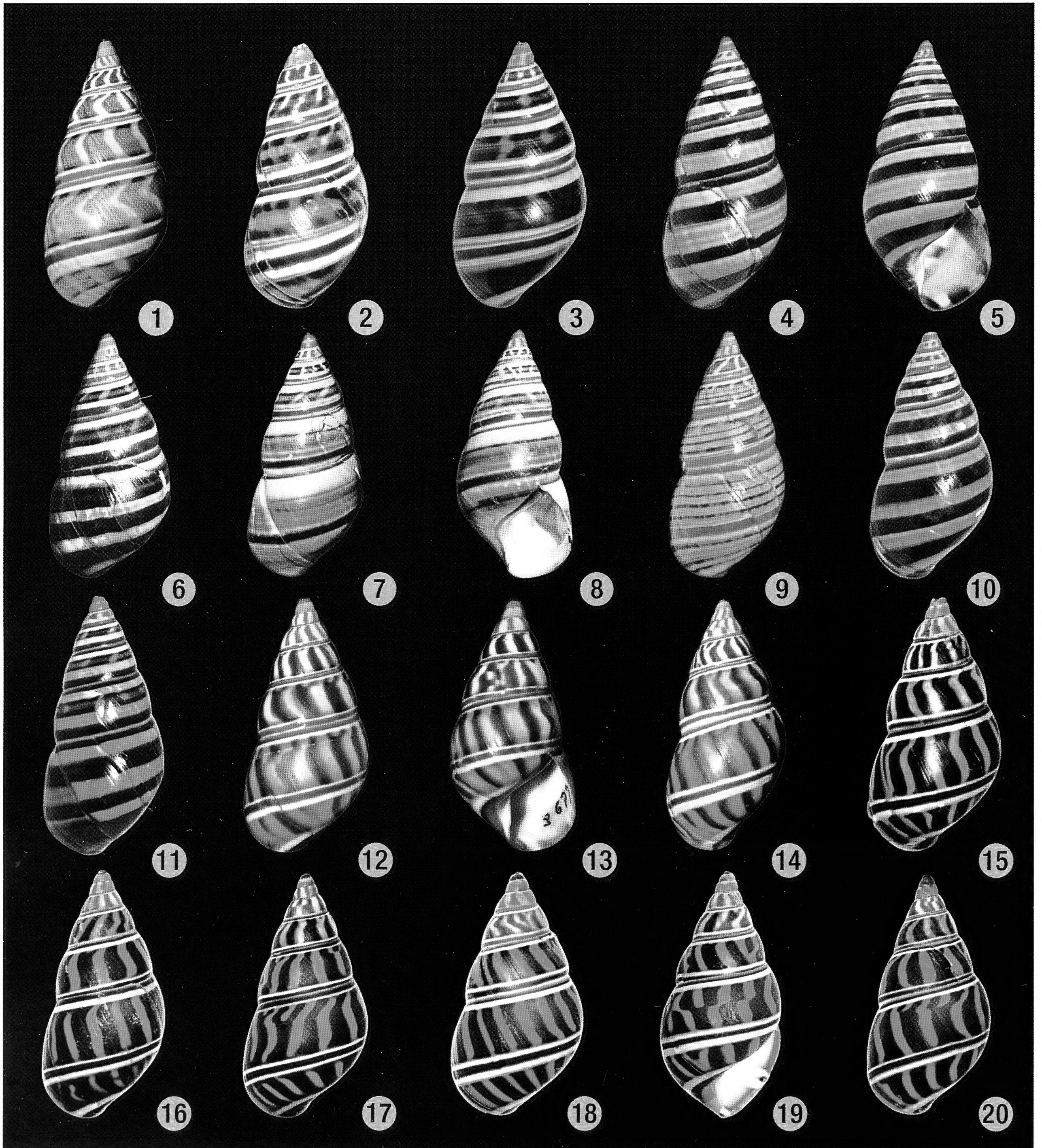


Plate 2. *Liguus blainianus* hybrids. Figures 1: *Liguus blainianus* hybrid, “Rangel” vicinity; 2-11: *Liguus blainianus* hybrids, Santa Cruz River Canyon-Arroyo del Loro area; 12-13: *Liguus blainianus pilsbryi* paratype [Felipe Poey Museum, Havana], Campo de Tiro; 14-20: *Liguus blainianus pilsbryi* topotypes, Campo de Tiro. All specimens are from the San Cristóbal municipality, Pinar del Río province, western Cuba.

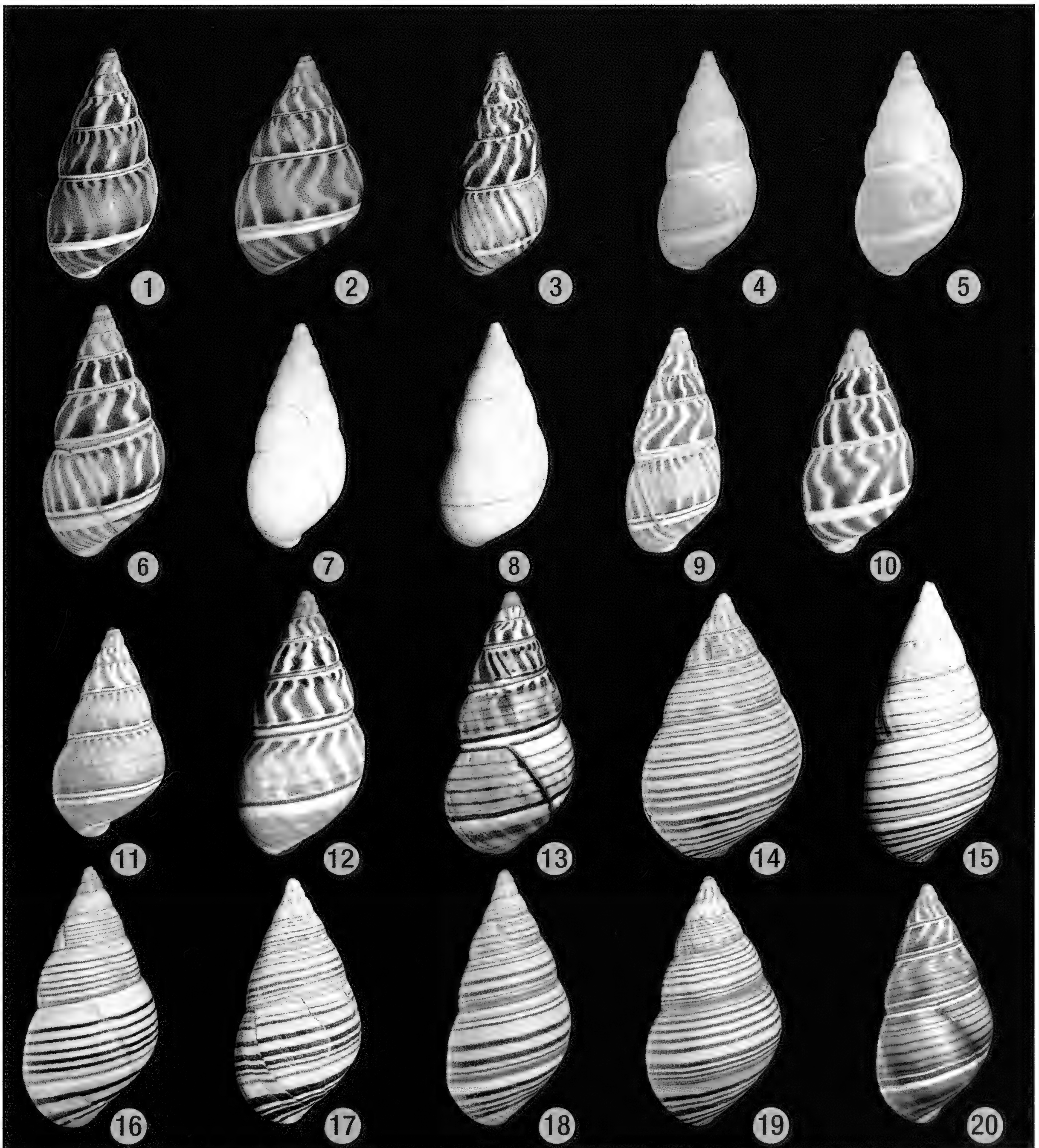


Plate 3. Other *Liguus blainianus* and *Liguus fasciatus* lineages. Figures 1-11: *L. b. murreus* lineage. 1: *L. b. fairchildi*, Güira de Melena; 2: *L. b. fairchildi*, Sierra de Anafe; 3: *L. b. fairchildi*, San Antonio de los Baños; 4: *L. b. guillermi*, Bauta; 5: *L. b. guillermi*, Batabanó; 6: *L. b. giganteus*, Finca Sotolongo, Güira de Melena; 7-8: *L. b. jaumei*, between Artemisa and Cañas towns; 9: *L. b. picturatus*, Ceiba del Agua; 10: *L. b. picturatus*, Hollywood beach, near Baracoa; 11: *L. b. minutus*, Puente de La Lisa, Havana city. All previous localities from Havana city and countryside. Figs. 12-13: *L. f. pallidus* lineage. 12: *L. b. guanensis*, Cueva del Obispo, Sierra de Guane; 13: *L. b. guanensis*, Los Portales, Guane. Figs. 14-20: *L. f. archeri* lineage. 14: *L. f. archeri*, Loma de Seboruco; 15: *L. f. archeri*, Las Yeguas, San Diego de los Baños; 16: *L. f. archeri*, Cañón del Río Santa Cruz; 17-18: *L. f. archeri*, Cañón del Río San Francisco; 19: *L. f. archeri*, Loma El Salon; 20: *L. f. ramosi*, Soroa hills. All specimens are from the Pinar del Río province, western Cuba.

The Fossil Cypraeidae of the Fruitville Member (Unit 4) and Kissimmee River Valley Equivalent, Tamiami Formation of Southern Florida: (Mollusca: Gastropoda: Cypraeidae)

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ABSTRACT The disappearance of all Pinecrest and equivalent Cypraeidae species from most of their habitats was caused by the circa 200,000 year cooling period in the mid Piacenzian Pliocene, c. 3.2-3.0 mya, and the associated significantly lower sea levels and dry terrestrial conditions in southern Florida. The cooling period was followed by a warming period, which resulted in the Tamiami Subsea being flooded to its maximum size and produced wide-spread tropical conditions throughout southern Florida, roughly similar to today's southwest Pacific. This resulted in the renewed radiation and speciation of the Cypraeidae populations. In the Myakka Lagoon System, the eight Pinecrest Member (Unit 7) Cypraeidae species in five genera were followed by ten new species in five genera which emerged in Fruitville (Unit 4) time. In the Kissimmee River Valley, the five Unit 7 equivalent species in three genera were followed by eight new species in three genera, which emerged in that area. The number of genera remains consistent at three with the only species previously assigned to *Pseudadusta* Petuch, 2004 placed into synonymy with *Akleistotoma bairdi* (Petuch, 2004). This represented a continuation of geographically separate, but parallel, evolutionary tracks.

KEYWORDS Tamiami Formation, Fruitville Member (Unit 4), Black Layer, Unit 4 equivalent, Fruitville Member (Unit 3), Unit 3 equivalent, Golden Gate Member, Cypraeidae, fossil, *Akleistostoma*, *Siphocypraea*, *Pahayokea*, *Calusacypraea*, *Pseudadusta*, Myakka Lagoon System (Myakka), Sarasota area, Kissimmee Embayment, Kissimmee River Valley (Kissimmee), Caloosahatchee Strait, Loxahatchee Strait, Okeechobee Plains, Everglades Pseudoatoll.

Pinecrest Member Extinguished

The extinguishment of the Pinecrest Member and its Cypraeidae species was marked by a mid-Piacenzian cooling period of about 200,000 years, c. 3.2-3.0 million years ago ("mya"), which is reflected in Units 6 and 5 that mirrored Unit 9 and 8 conditions in the Myakka Lagoon System (Myakka), present day Sarasota area. (see Daughenbaugh, J.D., 2019, Festivus 51(1) and 51(2).) The reduced sea levels produced dry, terrestrial conditions throughout much of southern Florida. This is reflected in unconformities (missing layers or strata) in

many of those areas. In both Myakka and Kissimmee this greatly constricted the sea grass and mud flat Cypraeidae habitats, resulting in the disappearance of all Pinecrest species. Isolated pockets undoubtedly remained and formed the basis for the radiation and speciation, which occurred during the subsequent Fruitville Member units of the mid to late Piacenzian.

Southern Peninsular FL (Fruitville Units 4)

The mid-Piacenzian, c. 3.0 mya, marked the commencement of the Fruitville Member of the Tamiami Formation. Following the end of

Pinecrest time period, southern Florida commenced a warming trend that progressively produced the warmest and most tropical conditions of the entire Pliocene. This was manifested in the highest sea levels in the Tamiami Subsea, which encompassed Myakka, Kissimmee and the Everglades Pseudoatoll.

South of Myakka and Kissimmee, the Everglades pseudoatoll was home to the molluscan species that inhabited the tropical coralline Golden Gate Member of the Tamiami Formation. The pseudoatoll was U-shaped, open in the north, and bounded by coral reefs and coral reef tracts encompassing the present day Everglades on the east, south and west. (see Figure 1.) Experiencing periodic flooding and emergent events, the pseudoatoll grew in fits and starts but achieved its maximum development during Fruitville 4 time with coral species diversity and population densities at a level similar to today's southwest Pacific. It would remain separate from peninsular Florida until the Pleistocene when sediments would fill

the remaining gaps. Today, the buried remnants along the rims of the reef tracts form the higher elevation areas adjacent to the Everglades. The southeastern coastal cities from Palm Beach to Miami rest on the underlying rim-like features. (see Daughenbaugh, J.D., *Festivus* 51(3) for full discussion and treatment.)

Fruitville and Contemporary Members, Tamiami Formation

In 1990, Waldrop and Wilson proposed the "Fruitville Formation" for the Pliocene sequence at Sarasota (Petuch Units 10-1) as most of the members of the Tamiami Formation lacked formal descriptions. Fruitville is a small town east of Sarasota, Florida. All units above Unit 11 at the APAC pit were included in the new formation and were put forward in replacement of the Pinecrest Member, which was then only broadly described. The authors' work was based on a biostratigraphic approach that created a proposed biozone.

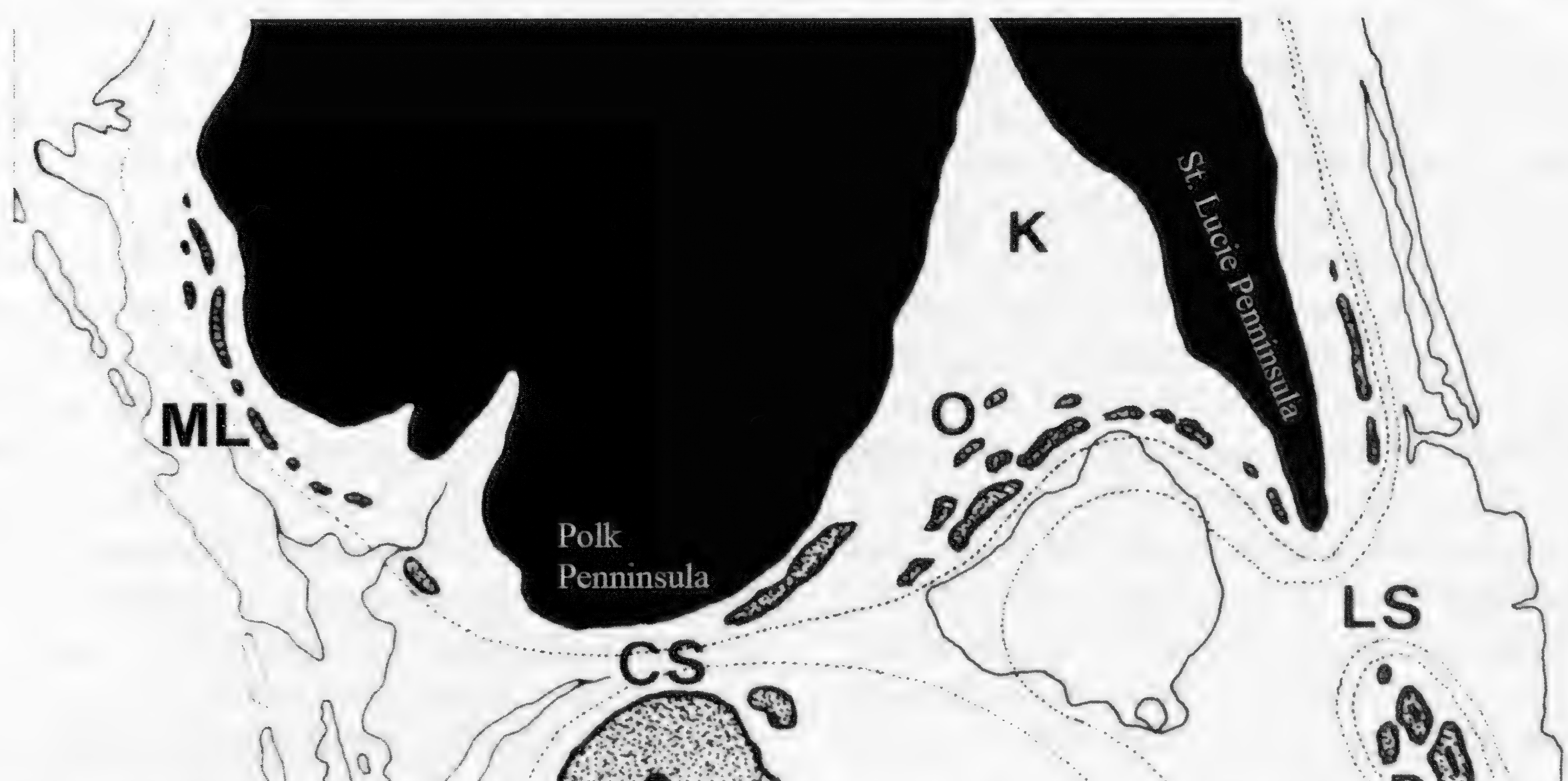


Figure 1. Map reflecting the Tamiami Subsea. ML = Myakka Lagoon System; K = Kissimmee Embayment; O = Okeechobee Patch Reefs; CS = Caloosahatchee Strait; LS = Loxahatchee Strait. Adapted from Petuch *et al.* 2018, figure 1.5 at p. 37.

Biostratigraphy relies on the correlation and assignment of relative ages of rock strata based on the fossil assemblages contained within the strata.

However, today, modern geology uses lithology (the physical characteristics of a rock unit) to identify individual formations and their members. Formations (aka geological formations), which are further divided into members, are the fundamental units of lithostratigraphy. Lithostratigraphy is based on the readily visible physical characteristics of rock strata or layers, not fossil assemblages. As such, Petuch assigned Units 9-5 at Sarasota to the Pinecrest Member as the lithology aligns with the Olsson and Petit (1964) description as refined by Missimer, T.M. (1992). Further, as "Fruitville Formation" had been used by a number of workers, including Emily Vokes, Petuch retained the name to differentiate the lithography of Units 4-2 at Sarasota as a member, *i.e.* the Fruitville Member.

Fruitville Member Beds

The Fruitville Member beds are composed of interbedded, *i.e.* alternating beds, of organic rich quartz sand, quartz sand with small amounts of clay and muddy quartz sand densely packed with fossil shells and fragments, many of which have taken on the coloration of the surrounding matrix. The alternating beds were produced by sea level variations that produced layers of unconformity (missing layers) in areas, which were emergent when sea levels dropped, especially during Units 3 and 2 time. The sea level changes also altered the depth of the remaining molluscan habitats. The Fruitville beds have thinner quartz sand beds that are muddier and contain more clay than Pinecrest beds.

Fruitville (Unit 4) Myakka Lagoon System

In the west, the prior Pliocene Cypraeidae habitats (Buckingham Unit 10 and Pinecrest Unit 7) were largely confined to sea grass beds with a small number of specimens exhibiting some black/blue staining characteristic of muddy, brackish habitats. However, by Fruitville Unit 4 time, Myakka, present day Sarasota region, was flooded producing what became the largest and best developed mangrove forests of the Tamiami Subsea. The mangrove forests formed a niche habitat along the coast line of the estuarine Myakka. These probably resembled similar forests in New Guinea and, along with associated intertidal mud flats and tidal channels, contained the richest estuarine molluscan fauna of the American Pliocene. The Fruitville basal Unit 4 is thickest and best developed at Myakka.

In the muddy peat layers at Sarasota, the most iconic of the Unit 4 Myakka habitats, darkly stained tannins leached from decaying vegetation in an oxygen poor, sulfuric environment. Small iron pyrite crystals (aka fool's gold) are often found attached to molluscan fossils and quartz sand grains. This is associated with brackish, swamp like muddy estuaries and coastal marshlands and produced many black, blue and/or tan stained fossil Cypraeidae specimens. Thus, the "Black Layer" designation. Fossil specimens recorded from such areas commonly exhibit such staining. For species confined to such habitats, Petuch proposed the subgenera *Akleistostoma* (*Paludacypraea*) Petuch and Drolshagen, 2011. Two Unit 4 species are assigned to the subgenera (see list in Table 1 below).

Separately, intertidal mud banks, adjacent to and encroaching on the mangrove jungles, provided the habitat for *Calusacypraea* Petuch, 2004 sp. (see below). In slightly deeper water

(1-3 m), mud bottoms and tidal channels hosted extensive beds of the small mactrid bivalve (estuarine associated) *Mulinia sapotilla* Dall, 1898. These were interspersed with sea grass beds in open areas along the edges of the banks and channels. These were inhabited by other Cypraeidae species, such as *Pseudadusta metae* (Petuch, 1994). Generally, these are not stained black/blue. However, some specimens occasionally exhibit such staining or tan/brown staining, suggesting they lived in close enough proximity to sometimes encroach on the Black Layer habitat.

Myakka Cypraeidae populations, which had been largely isolated in the Pinecrest saw cracks in this isolation. Several Unit 4 species have been reported from both Myakka and the Golden Gate of the Everglades Pseudoatoll in Lee and Collier Counties (see below). However, the neotenic Cypraeid genus *Calusacypraea* (Petuch, 1996) remained isolated in Myakka throughout Pinecrest and Fruitville times.

Fruitville (Unit 4) Kissimmee River Valley Equivalent

In the east, the Kissimmee Embayment and its southern sedimentary deposits formed a long and broad river valley (Kissimmee), which represented its southernmost extension. Following the 200,000 year cooling period that severely reduced molluscan habitats, these habitats were restored and reached their maximum expansion during Unit 4 time. Wide, shallow (1-5 meters deep) banks of compacted silica based river sediments, interspersed with tidal channels, dominated the central area within Kissimmee. The banks supported extensive sea grass beds that formed the habitats for several Cypraeidae populations.

As at Myakka, Kissimmee also hosted muddy estuarine and mangrove forest habitats. The

associated mudflats were intertidal and served as the restricted habitat of the neotenic genus (juvenile characteristics retained in adults) *Okeechobea* Petuch, 2004. The species in the genus (see below) evolved along a geographically separate but parallel track with the Myakka *Calusacypraea* species. Near shore, intertidal mud flats also served as the habitat for *Akleistostoma (Ingramicypraea) cliffordi* Petuch and Drolshagen, 2011 and *Pahayokea gabriellae* (Petuch, 2004). The latter's broad and flattened shape was ideal for fine particulate mud habitats.

The Unit 4 equivalent sedimentary facies differ from the Pinecrest and Myakka. Consisting of muddy, organic rich sand packed with shell fragments, the facies lacked the high percentages of mud and clay present in the Pinecrest Unit 7 equivalent facies. Its organic rich, grayish sand also does not reflect the high sulfide content and pyrite crystals of Unit 4 at Myakka.

As the sedimentary facies formed a continuum throughout Units 4 and 3 equivalents, it is necessary to rely on Index Fossils in order to assign the Cypraeidae aggregations to the appropriate equivalent unit. Also inhabiting the sea grass beds were a number of shallow water bivalves which serve as Index Fossils. These included *Cardita seminolensis* Olsson, 1957, *Pleuromeris pitysia* (Olsson, 1967) and *Carditamera dasytes* Olsson, 1967 among others. These were recorded in the lowest Fruitville beds at Kissimmee (Unit 4 equivalent) and have also been recorded from Unit 4 at Sarasota. The Unit 4 equivalent Cypraeidae species were recorded among and adjacent to those beds.

Long thought to be isolated within the Kissimmee, two Unit 4 equivalent species have also been reported from the Golden Gate

Member, Bonita Springs, Lee County (see below).

Unit 4 Transition

The Unit 4 transition at Myakka and Kissimmee was marked by falling sea levels, resulting in reduced and altered habitats. At this time, Unit 4

Cypraeidae species were replaced by new species in a sequential evolution as the populations adapted to the altered habitats during the subsequent Unit 3 time. Altogether, 19 species in six genera have been collected in Fruitville Unit 4 deposits and its equivalent. (see Table 1 below)

Fruitville Member Species – Unit 4 (G = also reported from the Golden Gate):

Myakka Lagoon System (Sarasota) Unit 4:

- Akleistostoma olssoni* Petuch and Drolshagen, 2011
- Akleistostoma* (*Mansfieldicypraea*) *macbrideae* (Petuch, 1998)
- Akleistostoma* (*Paludacypraea*) *cookei* Petuch and Drolshagen, 2011
- Akleistostoma* (*Paludacypraea*) *fruitvillensis* Petuch and Drolshagen, 2011
- Akleistostoma* (*Dallicypraea*) *williamdalli* Petuch and Drolshagen, 2011
- Siphocypraea* (*Seminolecypraea*) *grovesi* Petuch, 1998 (G)
- Pahayokea* (*Gardnericypraea*) *jenniferae* (Petuch, 1998) NOTE
- Calusacypraea tequesta* (Petuch, 1996)
- Calusacypraea* (*Myakkacypraea*) *myakka* Petuch, 2004
- Pseudadusta metae* (Petuch, 1994) (G)

Kissimmee Embayment (Kissimmee Valley restricted) Unit 4 equivalent:

- Akleistostoma* (*Ingramicypraea*) *cliffordi* Petuch and Drolshagen, 2011
- Akleistostoma* (*Olssonicypraea*) *bairdi* Petuch 2004*
- Pahayokea rucksorum* (Petuch, 2004) (G)
- Pahayokea gabrielleae* (Petuch, 2004) (G)
- Pahayokea basingerensis* (Petuch, 2004)
- Pahayokea* (*Kissimmecypraea*) *eddiematchetti* Petuch and Drolshagen, 2011
- Okeechobea waldroni* Petuch and Drolshagen, 2011
- Okeechobea* (*Yeehawcypraea*) *matchetti* Petuch and Drolshagen, 2011

* Reclassification

NOTE: The *Pahayokea* subgenus *Gardnericypraea* is under study.

Table 1. Fruitville Cypraeidae species in the Unit 4 transition at Myakka and Kissimmee.

Originally placed in the *Pseudadusta* Petuch, 2004 genus as *Pseudadusta judei* Petuch and Drolshagen, 2011, the Holotype of the *P. judei* was described as apical sulcus slightly curved, aperture narrow, becoming wider at the anterior end, posterior columellar teeth becoming obsolete. The specimen illustrated in Jewels of

the Everglades (7.5, D, E) and the specimen illustrated in the 2011 Compendium of Florida Fossil Shells (4.29, G, H, I) wherein the species was originally described reflect these features. However, the *Pseudadusta* genus was described as apical sulcus simple slot-like, narrow aperture with strong dentition. The features of

the species do not align with the features of the *Pseudadusta* genus.

In contrast, the subgenus *Olssonicypraea* Petuch and Drolshagen, 2011 was described as “round-to-oval, flattened cowries with thickened margins and narrow apertures” (Petuch *et al.* 2018, p. 56). *Olssonicypraea* apertures do widen at the anterior end, but less than other *Akleistostoma* species. Both Figures 2.22, D, E, *A. (O.) bairdi* and 7.5, D, E, *P. judei*, illustrated in Jewels, exhibit the features of the subgenus *A. (Olssonicypraea)*. Both were collected in the Unit 4 equivalent of the Kissimmee. The referenced Figures show specimens that are light weight with dentition which is not fully developed. They accord with what would be expected in young, dwarf *A. (O.) bairdi*. As specimens mature, they become progressively more callous. Figure 4 herein illustrates this progressive callousity. Accordingly, the taxon is placed into synonymy with *Akleistostoma (Olssonicypraea) bairdi*.

As no other *Pseudadusta* species have been reported or recorded from Kissimmee, the genus appears to be restricted to Myakka and the Golden Gate Member of the Everglades Pseudoatoll. The latter are separated from Kissimmee by the massive Polk Peninsula to the west as well as the narrow, deep water Caloosahatchee and Loxahatchee Straits to the south. In addition, intracapsular direct development and the associated restricted migration may be inferred based on the sister genus, *Muracypraea* Woodring, 1957 and the Recent *Muracypraea mus* Linnaeus, 1758 complex. The absence of either an ancestor or successor *Pseudadusta* species or a viable path of migration into Kissimmee from known *Pseudadusta* areas means the presence of the genus *Pseudadusta* in Kissimmee is unsupported at this time.

For detailed genera and species descriptions, background information and discussion, see Jewels of the Everglades, The Fossil Cowries of Southern Florida, 2018, by Edward J. Petuch, David P. Berschauer and Robert F. Myers. Dr. Petuch is Professor Emeritus, Florida Atlantic University where he was a professor of geology in the Department of Geosciences.

Origins

At Myakka (Sarasota), with the exception of *P. (G.) jenniferae*, all Unit 4 species are associated with the estuarine environments of Myakka, some with the brackish, swamp like muddy estuaries and coastal marshlands and others with the adjacent sea grass beds. The few specimens collected of *P. (G.) jenniferae*, with its rarity and lack of black staining on specimens, suggest it probably inhabited slightly deeper water sea grass beds.

Akleistostoma olssoni and *A. (M.) macbrideae* appear as offshoots of *Akleistostoma floridana* (Mansfield, 1931). At Sarasota (also present in the golden Gate Member), *S. (S.) grovesi* is most similar to the older *Siphocypraea (Seminolecypraea) trippeana* Parodiz, 1988, its probable ancestor. *Pseudadusta metae* is most similar to the earlier *Pseudadusta hertweckorum* (Petuch, 1991) while *A. (D.) williamdalli* is a unique, highly derived species with both *Akleistostoma* and *Pseudadusta* features. Its speciation represents an adaptation to the estuarine Black Layer environment and it disappeared at the end of Unit 4 time leaving no successors. The *Paludacypraea* species (paluda is latin for swamp) shared the same estuarine environment as *A. (D.) williamdalli* with most species exhibiting the associated black staining. The *Paludacypraeas*' twisted columellar outline and pseudofossula projecting into the aperture are unique to these species, features not shared with any known ancestor. *Calusacypraea*

tequesta represents a more globose and rounded *Calusacypraea duerri* (Petuch, 1996) while the ancestor of *C. (M.) myakka* is not known.

At Kissimmee, *A. (I.) cliffordi* (confirmed as Unit 4 equivalent) is most similar to the older *Akleistostoma (Ingramicypraea) highlandensis* Petuch and Drolshagen, 2011, but more elongate. Similarly, *A. (O.) bairdi* presents as a slender and more pyriform, among other features, *Akleistostoma (Olssonicypraea) hughesi* (Olsson and Petit, 1964). *Pahayokea rucksorum* and *P. gabriellae* represent sympatric species, *i.e.* species descended from a common ancestor while inhabiting the same geographic region. The more globose, inflated and domed *P. rucksorum* inhabited turtle grass beds while *P. gabriellae* inhabited mud flats. Their ancestor and the ancestor to *P. basingerensis*, named for its type locality of Fort Basinger, Highlands County, are unknown, although the latter has also been recorded from Rucks Pit, Okeechobee to the north. *Okeechobea waldroni* is most similar to the older *Okeechobea osceolai* Petuch and Drolshagen, 2011, but is more elongate and cylindrical with a narrower aperture while *O. (Y.) matchetti* is much broader and more inflated than the older *Okeechobea (Yeehawcypraea) bartoni* Petuch and Drolshagen, 2011.

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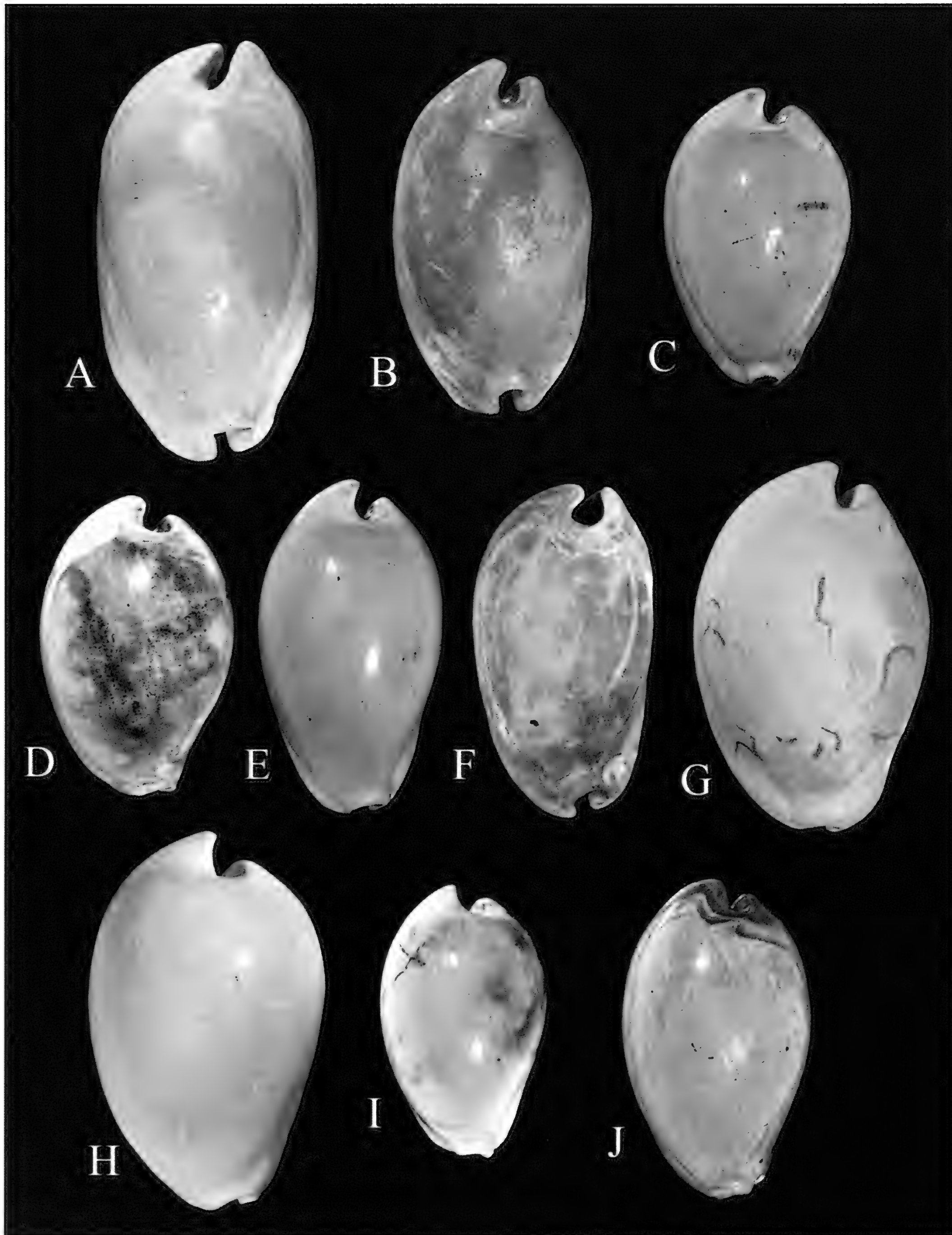


Figure 2. Myakka Lagoon System, Sarasota (Unit 4). A = *Akleistostoma olssoni* Petuch and Drolshagen, 2011, length = 84.0 mm; B = *Akleistostoma (Mansfieldicypraea) macbrideae* Petuch and Drolshagen, 2011, length = 72.2 mm; C = *Akleistostoma (Paludacypraea) fruitvillensis* Petuch and Drolshagen, 2011, length = 59.8 mm; D = *Akleistostoma (Paludacypraea) cookei* Petuch and Drolshagen, 2011, length = 60.1 mm; E = *Akleistostoma (Dallicypraea) williamdalli* (Petuch and Drolshagen, 2011), length = 67.3 mm; F = *Siphocypraea (Seminolecypraea) grovesi* Petuch, 2004, length = 63.8 mm; G = *Pahayokea (Gardnericypraea) jenniferae* (Petuch, 1998), length = 74.3 mm; H = *Calusacypraea tequesta* (Petuch, 1996), length = 72.3 mm; I = *Calusacypraea (Myakkacypraea) myakka* Petuch, 2004, length = 55.0 mm; J = *Pseudadusta metae* (Petuch, 1994), length = 64.5 mm.

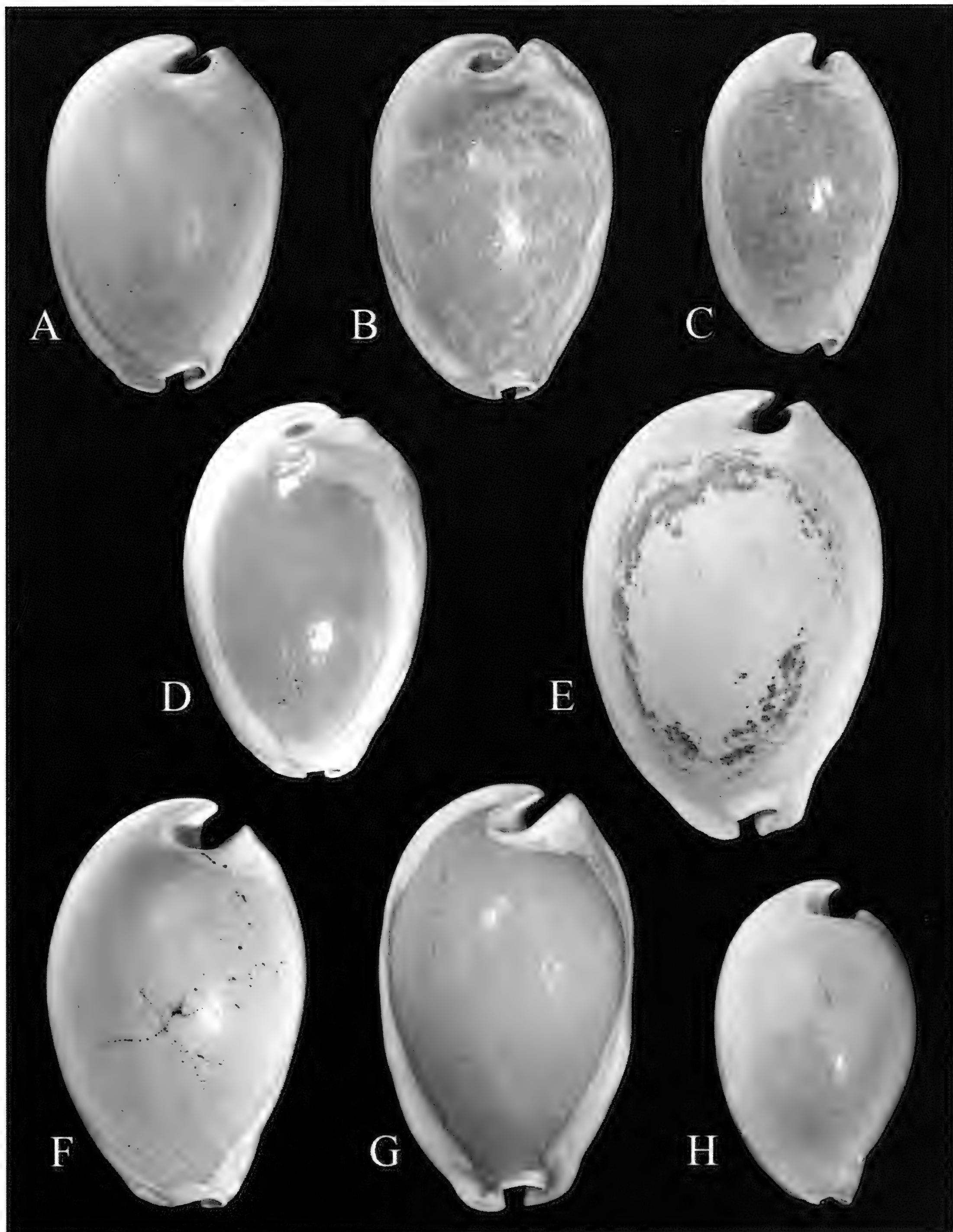


Figure 3. Kissimmee River Valley restricted (Unit 4 equivalent). **A** = *Akleistostoma* (*Olssonicypraea*) *bairdi* Petuch, 2004, length = 61.6 mm; **B** = *Pahayokea rucksorum* (Petuch, 2004), length = 59.7 mm; **C** = *Akleistostoma* (*Ingramicypraea*) *cliffordi* Petuch and Drolshagen, 2011, length = 53.2 mm; **D** = *Pahayokea gabrielleae* (Petuch, 2004), length = 61.7 mm; **E** = *Pahayokea basingerensis* (Petuch, 2004), length = 78.5 mm; **F** = *Okeechobea waldroni* Petuch and Drolshagen, 2011, length = 67.1 mm; **G** = *Pahayokea* (*Kissimmecypraea*) *eddiematchetti* Petuch and Drolshagen, 2011, length = 74.8 mm; **H** = *Okeechobea* (*Yeehawcypraea*) *matchetti* Petuch and Drolshagen, 2011, length = 55.9 mm.

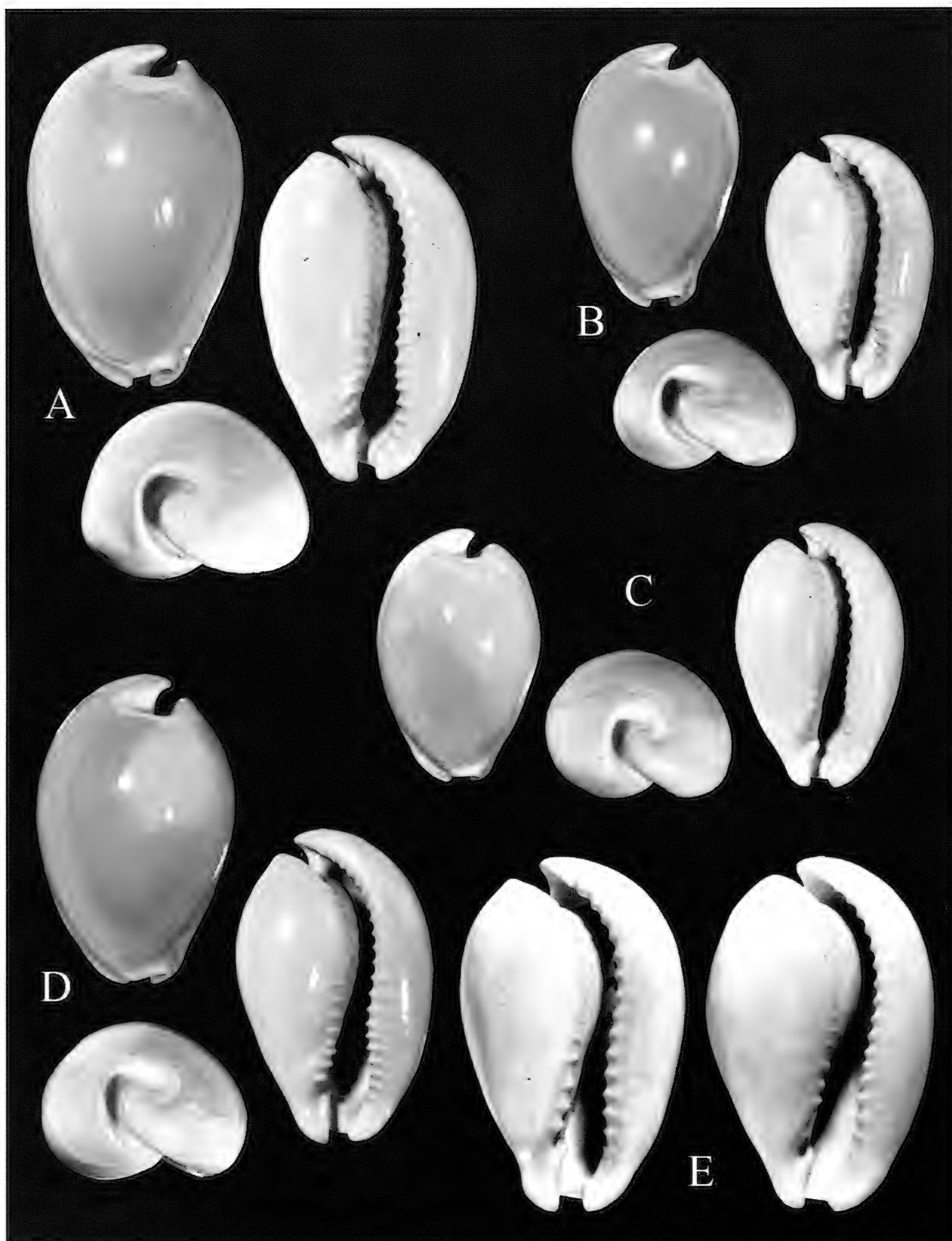


Figure 4. *Akleistostoma (Olssonicypraea) bairdi* Comparisons. A = 61.5 mm; B = 47.6 mm; C = 47.5 mm (aka *Pseudadusta judei* Petuch and Drolshagen, 2011); D = 56.1 mm; E = basal comparisons, left = *A. (O.) bairdi* vs. right *A. (O.) bairdi* (aka *P. judei*).

A Review of the Carolinian Province *Americoliva nivos*a Complex (Gastropoda: Olividae) with the Description of a New Subspecies

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ABSTRACT The common eastern North America and Gulf of Mexico olive shell, *Americoliva nivos*a (Marrat, 1871), is now known to comprise five separate subspecies that are distributed from Cape Hatteras to the Florida Keys, throughout the Gulf of Mexico to Isla Mujeres, and into the open Atlantic as far as Bermuda. The subspecies, which have disjunct distributions, include: *Americoliva nivos*a *clenchi* new subspecies (described here) which ranges from Cape Hatteras to Fort Pierce, Florida; *Americoliva nivos*a *bollingi* (Clench, 1934), which ranges from Palm Beach County, Florida south to the Florida Keys and Dry Tortugas; *Americoliva nivos*a *choctaw* Petuch and Myers, 2014, which ranges from Apalachicola to Pensacola along the Florida Panhandle of the northern Gulf of Mexico; *Americoliva nivos*a *maya* (Petuch and Sargent, 1986), which ranges from the Bay of Campeche to Isla Mujeres along the Yucatan Peninsula of Mexico; and *Americoliva nivos*a *nivos*a (Marrat, 1871), which is endemic to the island of Bermuda. All five of these distinct subspecies may have evolved from a common ancestor, the mid-Pleistocene (Ionian Age) *Americoliva nivos*a *murielae* (Olsson, 1967) from the Bermont Formation of southern Florida. A type locality is also designated for Marrat's non-localized *Americoliva nivos*a.

KEY WORDS Gastropoda, Olividae, *Americoliva*, *Americoliva nivos*a, *Americoliva nivos*a *clenchi*, North Carolina, Florida, Florida Keys, Gulf of Mexico, Yucatan, Bermuda, Bermont Formation

INTRODUCTION

The Carolinian Molluscan Province is now known to house a large number of distinct species and species complexes in the olivid genus *Americoliva* Petuch, 2013, with at least 12 recognizable taxa occurring within the province's five subprovincial subdivisions (Petuch, 2013; Petuch and Myers, 2014a). One of these, a Carolinian cluster of subspecies of the Caribbean Province *A. nivos*a (Marrat, 1871) (Bermudan Subprovince) was found to comprise five readily-separable taxa, with four being confined to Carolinian subprovinces and one to the Bermudan Subprovince of the Caribbean Province. The poorly-known

nominate subspecies, *A. nivos*a *nivos*a, had no recorded type locality and was essentially a *nomen dubium*. Based upon specimens from shallow water in Bermuda, this large, pink-colored olive was given the name "*Oliva* (*Strephona*)" *bifasciata jenseni* by Petuch and Sargent in 1986. The confusion over the status of Marrat's taxon was recently clarified by the refiguring of the type specimen of *A. nivos*a in color (in the "Mollusca Types of Great Britain" website). This has shown that the pale-colored Bermudan shells used by Petuch and Sargent to describe their subspecies *jenseni* were identical to the type lot of the true *A. nivos*a. A third member of this subspecies complex, *A. nivos*a *bollingi*, was described by Clench (1934) as a

southeastern Floridian subspecies of the widespread Caribbean Province *A. reticularis* (Lamarck, 1811). A fourth Carolinian member of the *A. nivosa* Complex, *A. maya*, was described from the Yucatan Peninsula (Yucatanian Subprovince) by Petuch and Sargent (1986) and is here referred to as *A. nivosa maya*. More recently, a new subspecies was also discovered and named “*A. bollingi choctaw*” (see Petuch and Myers, 2014b), adding a fourth taxon to the complex (considered here as *A. nivosa choctaw*). Since *A. nivosa* is the oldest name for the group, the cluster of subspecific taxa is referred to here as the “*Americoliva nivosa* Complex”. Once the geographical distributions of *A. nivosa* and its subspecies were better known and defined, we found that the large, darkly-colored “*A. bollingi*” from North and South Carolina, Georgia, and eastern Florida represented yet another unnamed subspecies. This distinctive taxon is described in the following sections and its discovery demonstrates that the *A. nivosa* Complex actually encompasses five distinct subspecies.

Much of the confusion surrounding the Carolinian *Americoliva* species is the result of the synonymies produced by Abbott (1974: 232). He considered *A. nivosa* to be merely a form of the widespread Caribbean Province *A. reticularis* (Lamarck, 1811), and also synonymized many other valid taxa under that single species (many were later resurrected in Petuch and Sargent, 1986). The true *A. reticularis* is now known to extend from the eastern Yucatan Peninsula, Cuba, the Bahamas, across the Antillean Arc and the Lesser Antilles, to Trinidad and northern Venezuela. This wide-ranging shell differs from the members of the *A. nivosa* Complex in having a much more inflated shell with more rounded sides and in having a much coarser and more diffuse color pattern (see Figure 3E, F). The taxonomic consolidation

that was initiated by Abbott was further compounded by Tursch and Greifeneder (2001), who considered most of the Carolinian and Caribbean *Americoliva* species to belong to a single taxon, *A. fulgurator* (Röding, 1798). That characteristic southern Caribbean olive, however, is now known to be endemic only to Aruba and northern Venezuela (Petuch, 2013: 133-135) and does not range across the entire western Atlantic. This excessive “lumping” of all of these “tent-patterned” olives has only led to the obfuscation of the evolutionary patterns that have occurred within the post-Pleistocene western Atlantic. The biogeographical and distributional patterns seen in the malacofaunas of the western Atlantic still offer the best insights into biodiversity, especially in taxa with non-dispersing direct larval development or short-lived veliger stages like those seen in many of the *Americoliva* species. Using this biogeographical approach, we here propose a new taxonomic framework for this conspicuous and important group of olive shells.

SYSTEMATICS

The members of the *Americoliva nivosa* subspecies complex are arranged here biogeographically by their resident subprovinces. The holotype of the new subspecies is deposited in the type collection of the Department of Malacology, Los Angeles County Museum of Natural History, Los Angeles, California and bears a LACM catalog number.

Class: Gastropoda
 Subclass: Orthogastropoda
 Superorder: Caenogastropoda
 Order: Sorbeoconcha
 Infraorder: Neogastropoda
 Superfamily: Volutoidea
 Family: Olividae
 Subfamily: Olivinae

Genus: *Americoliva* Petuch, 2013

The *Americoliva nivosa* Complex

Diagnosis. Shells of average size for the family Olividae and the genus *Americoliva*, distinctly cylindrical in shape, with straight sides and only slightly-rounded shoulders; spires proportionally low, subpyramidal or flattened; color patterns composed of variable amounts of triangular reticulations (“tenting pattern”) and amorphous zig-zags; mid-body of body whorl with two broad bands of larger and more darkly-colored zig-zag flammules, one anterior of the mid-body line and one posterior of the mid-body line; shell base colors usually in shades of canary yellow, pale yellow-tan, pale bluish-white, or pale pinkish-white; apertures uniformly narrow; columella ornamented with numerous strong teeth, with many having distinct bifurcations.

Discussion.

This complex of subspecies is almost completely confined to the Carolinian Province, with only one known extra-provincial outlier. Four of the subprovinces of the Carolinian Province, the Georgian, Floridian, Suwannean, and Yucatanian, each contain a single *A. nivosa* subspecies, with no known members of this complex being found along the Texan Subprovince of the Texan and northeastern Mexican coastlines (the individual subspecies are listed and discussed in the following sections). The single extra-provincial subspecies, *A. nivosa nivosa*, is endemic to the isolated North Atlantic island of Bermuda and is a biogeographical index taxon for the Bermudan Subprovince of the Caribbean Molluscan Province. Its presence on Bermuda demonstrates that the complex is present in two separate faunal provinces. The distributions of the *A. nivosa* subspecies and the extents of the

subprovinces of the Carolinian Province are shown here on Figure 1.

Of the Caribbean Province congeners of the Carolinian *Americoliva nivosa* Complex, *A. bifasciata* (Küster, 1878) is the most closely-related sister species. As seen here in Figure 3 C and D, this wide-ranging Caribbean olive differs from members of the *A. nivosa* complex in being a much squatter, more inflated and rotund shell, with rounded sides and a more rounded, less cylindrical shell profile. The Caribbean *A. bifasciata* also has a proportionally higher spire than its Carolinian sister species and subspecies to the north, which is structurally more similar to *A. sayana* (Figure 3A, B) than it is to the flatter-spined *A. nivosa* (Figure 2 A, B). The Caribbean and Carolinian sister species both exhibit two central bands of dark brown zig-zags, but that character occurs in most of the other Atlantic *Americoliva* taxa as well and simply represents a shared ancestral plesiomorphic state (see Petuch and Sargent, 1986 and Petuch, 2013 for illustrations of the other western Atlantic *Americoliva* species).

The *A. nivosa* Complex appears to have evolved within the Okeechobean Paleosea of southern Florida and later spread westward into the Gulf of Mexico and northward to the Carolinas and Bermuda. The oldest-known obvious member of the complex is *Americoliva nivosa murielae* (Olsson, 1967) (originally described as a full species; Figure 3G, H) from the Belle Glade Member of the Bermont Formation (Ionian Age of the mid-Pleistocene), which indicates that the complex is approximately 1 million years old.

1. Georgian Subprovince, Carolinian Province

Americoliva nivosa clenchi Petuch &
Berschauer, new subspecies
(Figure 2C, D)

Description. Named as a subspecies of the Bermudan endemic *Americoliva nivosa nivosa*; shell large for genus and species complex, elongated, distinctly cylindrical, with straight sides; shoulder slightly rounded; spire proportionally-low, subpyramidal, with spire whorls covered by thick callus; filament channel proportionally large and deep, bordered by thin, blade-like raised edge; aperture uniformly narrow, flaring slightly at anterior end; columellar area ornamented with 20-22 large, thin teeth, with anterior teeth occurring in bifurcated pairs; shell base color bright yellow-tan overlaid with dense network of darker tan and light brown triangular reticulations and nebulous flammules; mid-body bounded by 2 bands of darker brown triangular flammules arranged in zig-zag pattern; spire callus dark tan; interior of aperture pale violet or purple-tan; anterior end of columellar fasciole purple-tan in color; edge of filament channel along shoulder canary yellow in color, marked with scattered pale blue patches and numerous prominent dark brown, elongated hairlines.

Material Examined. HOLOTYPE - length 57 mm, width 24 mm, from Onslow Bay, North Carolina, LACM 3753. OTHER MATERIAL EXAMINED - Paratype 1: length 52 mm, width 21 mm, from off Fort Pierce, St. Lucie County, Florida, in the research collection of the senior author; Paratype 2: length 33 mm, width 16 mm, from off Jacksonville, Duval County, Florida, in the research collection of Pierre Recourt.

Type Locality. Trawled by scallop boats from 25 m depth on an *Argopecten gibbus*

carolinensis scallop bed, in Onslow Bay, south of Beaufort, Carteret County, North Carolina.

Distribution. This northern subspecies ranges from Cape Hatteras, North Carolina to off Fort Pierce, St. Lucie County, Florida and is confined to the Georgian Subprovince of the Carolinian Province.

Etymology. Named for the late Dr. William J. Clench of Harvard University, for many decades the preeminent authority on the systematics of the tropical western Atlantic mollusks and the first person to recognize *Americoliva nivosa bollingi* as a valid subspecies.

Discussion. Of the known geographical subspecies of *Americoliva nivosa*, *A. nivosa clenchi* is the largest, most elongated, and most darkly-colored. The large size and cylindrical shape of this northern subspecies has led many researchers and collectors to consider the shell to be only an offshore, deeper water variant of the common and widespread *A. sayana* (Ravenel, 1834) (Figure 3A, B). The new subspecies differs from its sympatric congener in being a wider, thicker, and proportionally more cylindrical shell, in consistently having a lower spire, and in being a more darkly-colored shell with a coarser network of triangular reticulations. The new subspecies, *A. nivosa clenchi*, is also similar to the southern Florida and Florida Keys *A. nivosa bollingi* in having a distinctly cylindrical shape, but differs in being consistently larger and more elongated and in having a darker color pattern composed of a dark yellow base color and dark tan reticulations. Both *Americoliva sayana* and *A. nivosa clenchi* occur together in the deeper water scallop beds found offshore of the Carolinas, Georgia, and eastern Florida.

2. Floridian Subprovince, Carolinian Province

Americoliva nivosa bollingi (Clench, 1934)
(Figure 2 A, B)

Range. From Jupiter, Palm Beach County, Florida south to Key West and the Dry Tortugas, Florida Keys, usually found in carbonate sand near living coral reefs. Specimens of *A. nivosa bollingi* were found together with *A. sayana* on the sand flats off Peanut Island, Lake Worth, Palm Beach County, demonstrating that the two congeners are sympatric.

Discussion. This distinctive subspecies originally was described as a subspecies of *A. reticularis* and was thought to represent a southern Florida population of that wide-ranging Caribbean species. It is now known that *A. reticularis* (Figure 3E, F) is morphologically quite different from the Carolinian Province *A. nivosa bollingi* and represents a separate species lineage within the genus *Americoliva*. The Caribbean-restricted *A. reticularis* is a very inflated, almost ovate, shell with conspicuously rounded sides and with a higher, more protracted spire. The Caribbean congener also has a much more diffuse color pattern, composed of widely-separated zig-zag flammules and lacks the two mid-body bands that are so obvious on the members of the *A. nivosa* Complex. Although common in the Bahamas, *A. reticularis* has never been collected in Florida, in the Florida Keys, or anywhere else within the Carolinian Province.

3. Suwannean Subprovince, Carolinian Province

Americoliva nivosa choctaw
Petuch and Myers, 2014 (Figure 2E, F)

Range. Confined to the northern end of the Suwannean Subprovince, from the “Panhandle” of northwestern Florida and the northeastern Gulf of Mexico, from St. George Sound and Apalachicola Bay, Franklin County in the east to Pensacola Bay, Escambia County in the west.

Discussion. This isolated subspecies is the smallest member of the complex, averaging only 43 mm in length. Besides the consistent difference in size, *A. nivosa choctaw* also differs from the other sibling subspecies in having a noticeably squatter and more compressed shell with more rounded sides, in having a slightly higher spire, and in having a much finer reticulated triangle pattern on the body whorl. This is also the palest-colored member of the subspecies complex, with many specimens having only a pale tan or yellow-tan reticulated pattern.

4. Yucatanean Subprovince, Carolinian Province

Americoliva nivosa maya
(Petuch and Sargent, 1986) (Figure 2G, H)

Range. Confined to the Yucatan Peninsula of Mexico, from Isla Contoy, Quintana Roo in the east to Campeche in the west and encompassing the entire offshore Campeche Bank.

Discussion. Although originally described as a full species, distinct from other members in its genus, we now consider *maya* to be a subspecies of *A. nivosa*. This conclusion, corroborated by observations from Pierre Recourt, was reached because of the obvious similarities of *maya* with other members of the *A. nivosa* Complex. These include the cylindrical body shape, the proportionally low spire, and the presence of two dark brown bands of brown zig-zags around the mid-body. Most *A. nivosa maya* exhibit a bright canary yellow base

color, have a yellow color within the interior of the aperture, and have a yellow callus on the spire whorls. A pale yellow-colored population of the Mayan Olive has also been collected in shallow water near Isla Mujeres.

5. Bermudan Subprovince, Caribbean Province

Americoliva nivosa nivosa
(Marrat, 1871) (Figure 2I, J)

Range. Confined to the island of Bermuda.

Discussion. This is the only member of this close-knit subspecies complex that is found outside of the boundaries of the Carolinian Province, being confined to, and being a biogeographic index taxon for, the Bermudan Subprovince of the Caribbean Province. During the mid-Pleistocene, with warmer water temperatures and a faster-flowing Gulf Stream, the short-lived planktonic larvae of *A. nivosa murielae* made their way to the remote seamount of Bermuda. With no other olivid competitors and in complete genetic isolation, the Bermudan population of the Ionian-aged *A. nivosa murielae* evolved into the living *A. nivosa nivosa*. This member of the subspecies complex is the most morphologically-distinct of the five known taxa, having a pale pink or pinkish-white base color overlaid with a pale pinkish-tan reticulated pattern. The Bermudan subspecies also closely resembles the ancestral *A. nivosa murielae* (Figure 3G, H) in having the same cylindrical shape, flattened spire, and shell size.

Marrat (1871) gave no type locality for his “*Oliva*” *nivosa* (see Mollusca Types of Great Britain website) and the species name has been applied erroneously to many other Caribbean *Americoliva* species, most often variants of *A. bifasciata* and *A. figura*. An examination of

Marrat’s syntypes has shown that the taxon is identical to the holotype of “*Oliva (Strephona)*” *bifasciata jenseni* Petuch and Sargent, 1986 (deposited in the National Museum of Natural History, Smithsonian Institution, catalog number USNM 841453; see Petuch and Sargent, 1986, plate 21, figs. 16 and 17). Since Marrat’s *nivosa* is now known to be endemic to the island of Bermuda, we here designate its type locality as “2 m depth in sand, off Blue Horizons Beach, Paget County, Bermuda”.

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We thank the following people for their generous donation of specimens used in the research for this paper: Pierre Recourt, The Netherlands (*A. nivosa nivosa*); Linda Zylman, Palm City, Florida (*A. nivosa choctaw*); and, Luis Vela, Museo del Mar Mexico, Yucatan, Mexico (*A. nivosa maya*). Special thanks also go to Pierre Recourt for his conversations and great insights into the composition of the *Americoliva nivosa* Complex and other *Americoliva* species.

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Figure 1. Map showing the distributions of the five subspecies in the *Americoliva nivosa* Complex.

A= *Americoliva nivosa clenchi* Petuch and Berschauer, new subspecies; **B=** *Americoliva nivosa bollingi* (Clench, 1934);

C= *Americoliva nivosa choctaw* Petuch and Myers, 2014; **D=** *Americoliva nivosa maya* (Petuch and Sargent, 1986); **E=** *Americoliva nivosa nivosa* (Marrat, 1871).

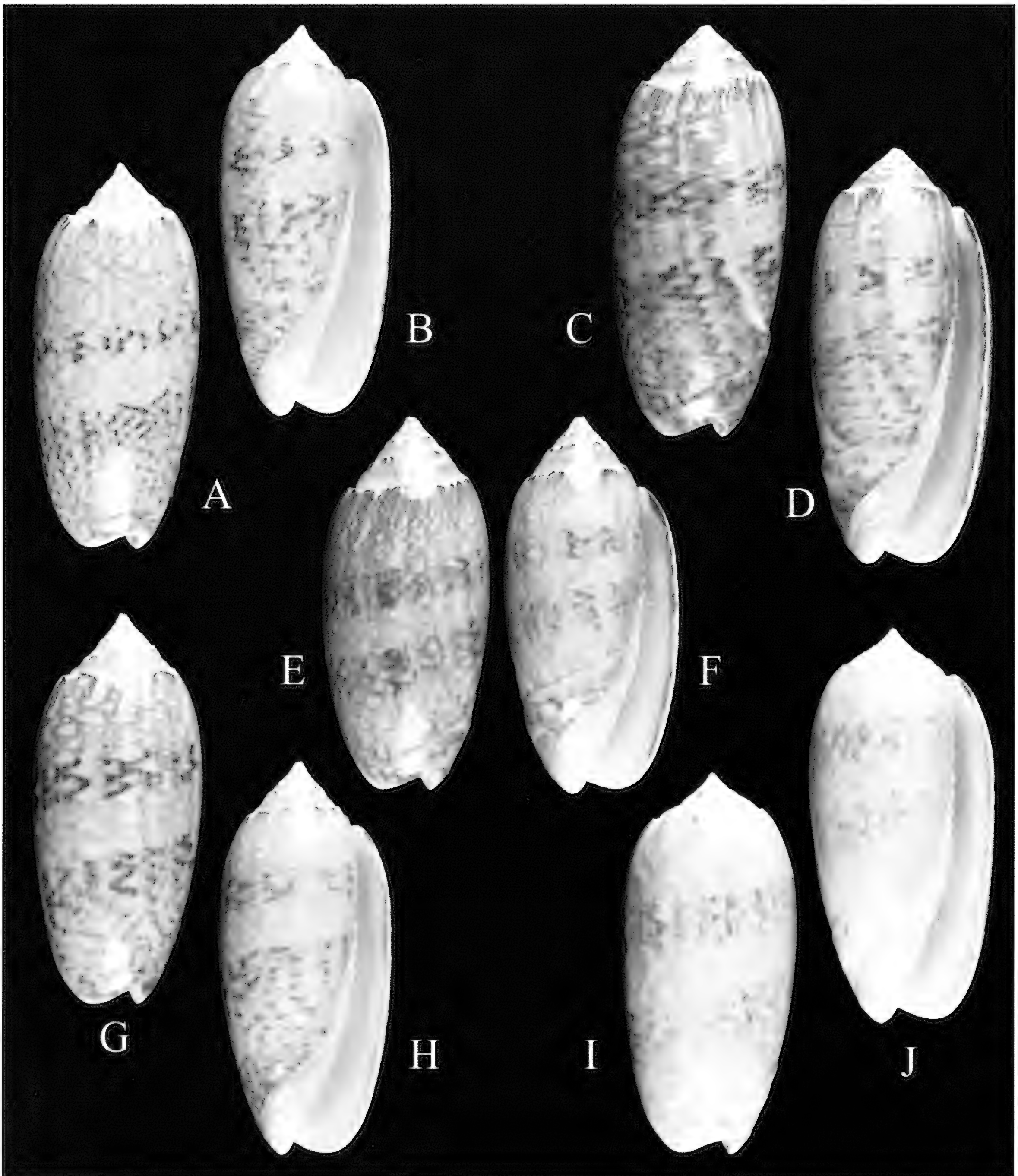


Figure 2. Subspecies of *Americoliva nivos* (Marrat, 1871). A, B= *Americoliva nivos bollingi* (Clench, 1934), length 52 mm, from 3 m depth on carbonate sand, off Boca Raton, Palm Beach County, Florida; C, D= *Americoliva nivos clenchi* Petuch and Berschauer, new subspecies, holotype LACM 3753, length 57 mm, trawled from 25 m depth in an *Argopecten gibbus carolinensis* scallop bed, in Onslow Bay south of Beaufort, Carteret County, North Carolina; E, F= *Americoliva nivos choctaw* Petuch and Myers, 2014, length 40 mm, in sand at low tide, St. Andrew Sound, Panama City, Bay County, Florida; G, H= *Americoliva nivos maya* (Petuch and Sargent, 1986), length 50 mm, trawled from 30 m depth off Isla Contoy, Quintana Roo, Mexico; I, J= *Americoliva nivos nivos* (Marrat, 1871), length 48 mm, from 2 m depth in sand off Blue Horizons Beach, Paget Parish, Bermuda; *A. bifasciata jenseni* (Petuch and Sargent, 1986) is a junior synonym).



Figure 3. Living and fossil *Americoliva* species from the Carolinian and Caribbean Provinces. A, B= *Americoliva sayana* (Ravenel, 1834), length 64 mm, 2 m depth in sand, off Jupiter Beach, Jupiter, Palm Beach County, Florida; C, D= *Americoliva bifasciata* (Küster, 1878), length 50 mm, 2 m depth in sand off the southern coast of Ile Gonave, Haiti; E, F= *Americoliva reticularis* (Lamarck, 1811), length 45 mm, low tide in sand, Nixes Harbour, South Bimini Island, Bahamas; G, H= *Americoliva nivosa murielae* (Olsson, 1967), length 49 mm, from the Belle Glade Member of the Bermont Formation, Ionian Age, Pleistocene. Collected in spoil piles from the dredging of the North New River Canal, 5 km south of South Bay, Palm Beach County, Florida.

A new species of *Amphidromus* (Mollusca: Gastropoda: Camaenidae) from Vietnam, and a Replacement Name for *Amphidromus berschaueri mingmini* Thach, 2019

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ABSTRACT A new species of genus *Amphidromus* Albers, 1850 is described from Vietnam and compared to two other species of this genus, *Amphidromus contrarius* (Müller, 1774) and *Amphidromus richardi* Severns, 2006. *Amphidromus berschaueri mingmini* Thach, 2019 is renamed to avoid homonymy.

KEYWORDS Gastropoda, Helicoidea, Camaenidae, *Amphidromus*, Bù Đăng, Bình Phước, Vietnam, *Amphidromus binhphuocensis*, *Amphidromus berschaueri mingi*, new taxon.

INTRODUCTION

The genus *Amphidromus* Albers, 1850 belongs to the family Camaenidae with many species collected in Vietnam. At the beginning of 2019, a new camaenid species was found. It was not listed in the works by Parkinson, Hemmen & Groh (1987), Abbott (1989), Schileyko (2011), Thach (2005, 2007, 2012, 2016, 2017) and Stark, 2017. It is here described as new to science. To avoid homonymy, *Amphidromus berschaueri mingmini* Thach, 2019 is renamed.

Abbreviations:

FMNH	Field Museum of Natural History, Chicago, USA
NNT	Collection Dr Thach
BT	Collection Bùi Tiến
AH	Aperture height
BH	Body whorl height
SH	Shell height
SW	Shell width

SYSTEMATICS

Class Gastropoda Cuvier, 1797
Superfamily: Helicoidea Rafinesque, 1815
Family: Camaenidae Pilsbry, 1895
Subfamily: Camaeninae Pilsbry, 1895
Genus: *Amphidromus* Albers, 1850
Type species of genus: *Helix perversus* Linnaeus, 1758

Amphidromus binhphuocensis Thach,
new species (Figures 1-8)

Description. Shell small for the genus (with height range 26.5-30.5 mm) elongate tapering with moderately tall spire and deep sutures. Shell width 53.3% of height (see Table 1 with measurements on four specimens). Body whorl inflated and occupying 67.8% of shell height, periphery rounded. Outer surface ornamented with a yellow spiral band at anterior part of body whorl and many broad axial stripes that are usually crossed by narrow white spiral lines. Sculpture consisting of fine, closely-spaced axial riblets and a green subsutural band followed by a brown stripe at each whorl. Aperture elongate-ovate with external pattern

visible within and occupying 49% of shell height, outer lip moderately thick and slightly reflected. Columella slightly curved, umbilicus closed. Color brown with white outer lip and columella, black apex and yellow spiral band. Type material was provided by Bui Thai Tien of Vietnam.

No.	1	2	3	4
SH (mm)	30.3	30.5	27.9	26.5
SW (mm)	15.3	15.7	15.6	14.8
SW/SH	0.50	0.51	0.56	0.56
Mean SW/SH	0.53			
AH (mm)	13.6	15.3	14.1	14.0
AH/SH	0.45	0.50	0.51	0.53
Mean AH/SH	0.49			
BH (mm)	19.8	20.8	19.0	18.5
BH/SH	0.65	0.68	0.68	0.70
Mean BH/SH	0.68			

Table 1. Morphometrics of *Amphidromus binhphuocensis* Thach, n. sp.

Diagnosis. The new species is characterized by broad, yellow spiral band at anterior body whorl and a green subsutural band followed by a brown stripe at each whorl.

Type Material. Holotype 30.3 mm in height FMNH with Registration No: FMNH-386365 (Figures 1, 2, 3, 4, & 8). Paratypes all from the type locality: Paratype 1: 30.5 mm in height (Figures 5 & 6) in NNT; Paratype 2: 27.9 mm high (Figure 7) and Paratype 3: 26.5 mm in height (not illustrated) in BT.

Type Locality. Bù Đăng District, Bình Phước Province, South Vietnam.

Habitat. Found among leaf litter around trees.

Etymology. The new species is named for the Bình Phước Province of Vietnam where type material was collected.

Discussion. The new species is distinguished mainly from *Amphidromus contrarius* (Müller, 1774) (see Figure 9) by having a less inflated body whorl, broader spire, less constricted sutures, no abrupt increase of diameter from penultimate to last whorl and absence of a white, calloused triangle situated near the posterior end of outer lip (marked by small red letter “t” on Figure 9). It is close to *Amphidromus richardi* Severns, 2006 (see Figures 10 and 11) but type localities are different (Vietnam compared to Indonesia), aperture is not angulate at the anterior extremity, body whorl more inflated, early whorls not pink, outer lip more regularly convex with posterior margin more ascending (not strongly turned rightward) and the white, narrow spiral band bordering columella is lacking. *Amphidromus xiengensis* Morlet, 1891 differs mainly from the new species in many characters such as (1) spiral band at anterior body whorl much narrower and interrupted (not continuous), (2) apex not black, (3) aperture without external pattern visible within. The new species is not compared to *Amphidromus yifengi* Wang, 2019 that is not available as it was published in “Jungle Rainbow” which does not meet the criteria of the ICZN for what constitutes a publication (Philippe Bouchet, personal communication, July 2019).

Amphidromus berschaueri mingi nom. nov.
(Figure 12)

Amphidromus berschaueri mingmini Thach, 2019 was recently described last quarter in The Festivus 51(3):231-236. With this article, it is renamed as *Amphidromus berschaueri mingi* nom. nov. in order to avoid homonymy with *Amphidromus mingmini* Wang, 2019 which, along with *A. yifengi* Wang, 2019, is invalid.

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I thank Dr. Jochen Gerber of the Field Museum of Natural History in Chicago, USA for providing the photo holotype of *Amphidromus richardi*. Thanks are also due to the reviewers for their useful comments.

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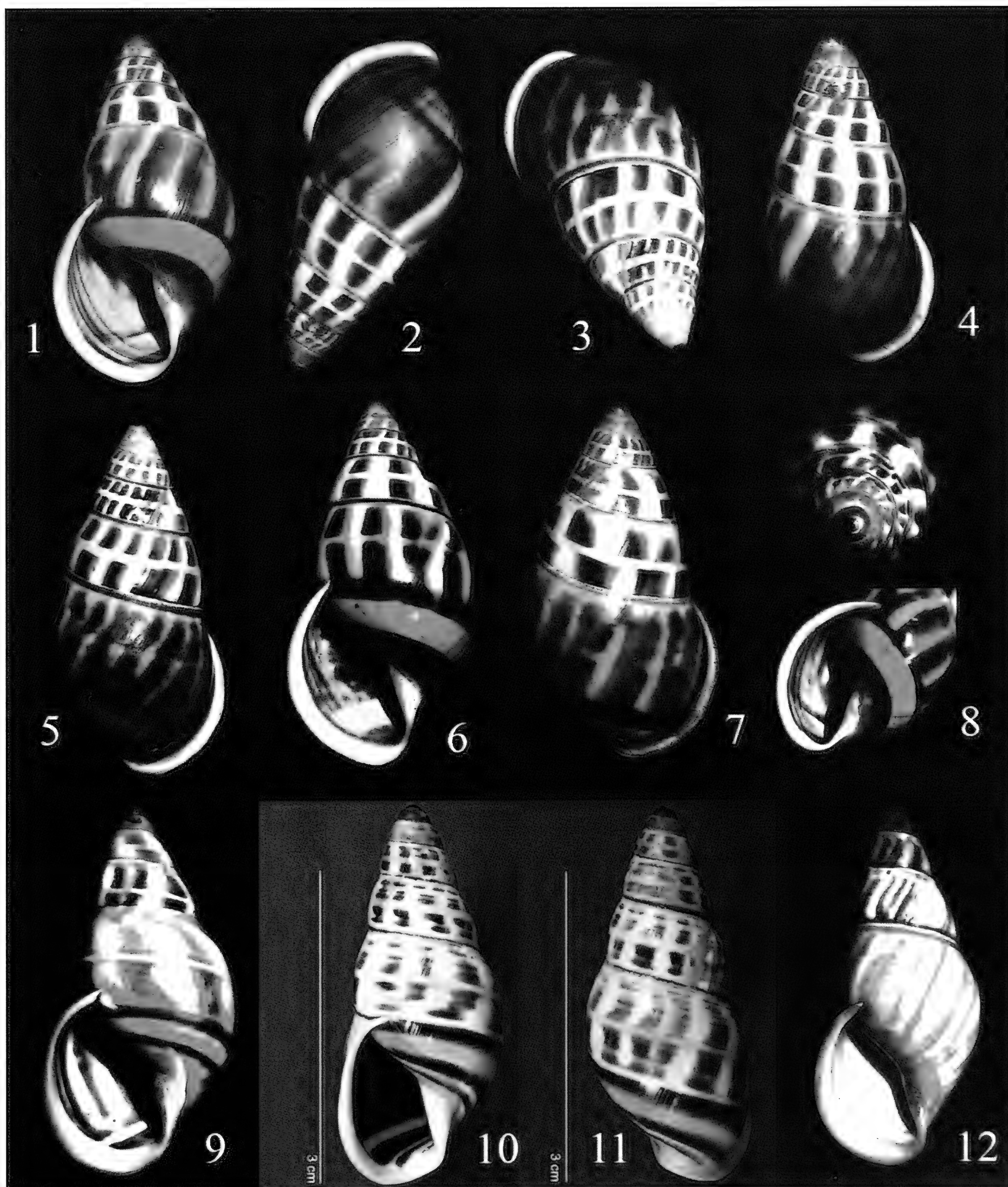


Plate 1. Comparison Images. *Amphidromus binhphuocensis* Thach, n. sp., Bình Phước, Vietnam: 1= Holotype 30.3 mm with ventral view in FMNH; 2 = Holotype with reflected outer lip; 3 = Holotype with spire view; 4 = Holotype with dorsal view; 5, 6 = Paratype 1, 30.5 mm with dorsal and ventral views; 7 = Paratype 2, 27.9 mm with dorsal view; 8 = Holotype with enlarged apex (top) and umbilicus (bottom); 9 = *Amphidromus contrarius* ventral view for comparison; 10, 11 = *Amphidromus richardi* (holotype FHNH 308029) with ventral and dorsal views for comparison, photo by courtesy of FMNH; 12 = *Amphidromus berschaueri mingi* nom. nov., 2019, 38.7 mm ventral view for comparison.

**Review on the synonymy concerning genus *Amphidromus* Albers, 1850
(Gastropoda: Camaenidae), with descriptions of new species**

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ABSTRACT This study rectifies several probable errors in recent research regarding synonymy of *Amphidromus* Albers, 1850, the infraspecific variation of which is extreme and can lead to improper nomenclature assignments. Two new species of *Amphidromus* recorded from Vietnam and Thailand are also described.

KEYWORDS Systematics, synonymy, *Amphidromus*, Vietnam, Thailand, Camaenidae, Helicoidea, Gastropoda, Mollusca, land snail, *A. fengae*, *A. bozhii*, new taxa

INTRODUCTION

Amphidromus Albers, 1850 is a highly diversified genus of terrestrial gastropods in Camaenidae, Helicoidea whose distribution range is extensive throughout southeast Asia. Due to the great variability of this genus, some authors (He & Zhou, 2017; Inkhavilay *et al.*, 2019), have synonymized several *Amphidromus* species which are likely valid. The synonymy likely arose as a result of the abundance as well as the inaccessibility of relevant literature (Thach & Huber, 2016; Inkhavilay *et al.*, 2017). These issues are analyzed in this study, with the conclusion that *Amphidromus richgoldbergi* Thach & Huber, 2017, *A. thakhekensis* Thach & Huber, 2017 and *A. pervariabilis* Bavay & Dautzenberg, 1909 ["1908"] are valid. *Amphidromus xiengkhuangensis* Inkhavilay & Panha, 2017 is synonymized with the older species *A. thanhhoaensis* Thach & Huber, 2016. In addition, two new species of *Amphidromus* from Indochina, viz. Vietnam and Thailand, are described based on materials that were obtained by the author and partially donated to the Da Lian Shell Museum.

Abbreviations.

AC	Author's collection
CUMZ	Chulalongkorn University Museum of Zoology, Bangkok
FMNH	Field Museum of Natural History, Chicago
DLSM	Da Lian Shell Museum, Da Lian
MNHN	Muséum National d'Histoire Naturelle, Paris
NHMUK	The Natural History Museum, London
SMF	Forschungsinstitut und Naturmuseum Senckenberg, Frankfurt am Main
UMMZ	University of Michigan Museum of Zoology

SYSTEMATICS

Class: Gastropoda Cuvier, 1797

Family: Camaenidae Pilsbry, 1895

Genus: *Amphidromus* Albers, 1850

Type species *Helix perversus* Linnaeus, 1758
by subsequent designation of E. von Martens
in Albers (1860)

Amphidromus richgoldbergi

Thach & Huber, 2017 (Plate 1, Figure A, B)

Amphidromus richgoldbergi Thach & Huber in
Thach, 2017: 45, figs 505–508. Type locality:
Vang Vieng, Vientiane Province, Central Laos
[Vangvieng District, Vientiane Province, Laos].
Amphidromus “*richgoldbergi*”: Sutcharit &
Panha, 2006: 26–28, figs. 4n–q, 18, 19.
Inkhavilay *et al.*, 2017: 14–15, figs. 2c, 3c, 4i.
Inkhavilay *et al.*, 2019: 90, figs. 43d–e.
(Synonymized as *Amphidromus givenchy* Geret,
1912).

Differential Diagnosis. This species can be
distinguished from *Amphidromus givenchy*
Geret, 1912 readily because the latter species
has a more elongate spire and striped
periostracum, whereas *A. richgoldbergi* have a
periostracum continuously covering the exterior
of its shell.

Materials Examined. Holotype of
Amphidromus richgoldbergi, FMNH 381986;
Syntype of *A. givenchy* Geret, 1912, MNHN-
IM-2000-2035; Three specimens of *A.*
richgoldbergi, collected in Bokeo Province
(Laos), in AC.

Amphidromus thakhekensis

Thach & Huber, 2017 (Plate 1, Figures C–E)

Amphidromus thakhekensis Thach & Huber in
Thach, 2017: 48, figs. 553–556. Type locality:
Thakhek, Khammouane Province, South-
Central Laos.

Amphidromus “*thakhekensis*”: Inkhavilay *et al.*,
2017: 32, figs. 9e–f, 12g–i, 13i–m, 14c–d.
Inkhavilay *et al.*, 2019: 89–90, figs. 42f, 43a–b.
(Synonymized as *Amphidromus fuscolabris*
Möllendorff, 1898)

Differential Diagnosis. There are a multitude
of *Amphidromus* species with similar pattern on
their shell, namely: *A. eudeli* Añcey, 1897; *A.*
fuscolabris Möllendorff, 1898; *A. thakhekensis*;
A. pengzhuoani Thach, 2018; and *A. goldbergi*
Thach & Huber, 2018. All but one of these
species occur in Laos. The later two species are
not discussed herein due to the lack of study
material. Some recently collected specimens,
which can be categorized as two color forms,
apparently belonging to one species (Inkhavilay
et al., 2017), are recognized as *A. fuscolabris*
by some authors (Inkhavilay *et al.*, 2017;
Inkhavilay *et al.*, 2019). Preliminary
observation on the morphology of currently
available materials reveals that the penultimate
whorl of specimens recently collected in Laos is
significantly larger in comparison to the total
shell height and these specimens have larger
apertures. Furthermore, a new specimen
collected in Vietnam exhibits more resemblance
to the holotype of *A. fuscolabris*, however,
similar individuals have not been reported from
Laos since the publication of *A. fuscolabris*.
This implies that the original geographic record
of *A. fuscolabris* is not congruent with its actual
distribution range. In conclusion, *Amphidromus*
thakhekensis is a valid name referring to CUMZ
7041–7042 and other recently collected Laotian
specimens alike.

Materials Examined. Holotype of *Amphidromus fuscolabris* (SMF 7641); Holotype of *Amphidromus thakhekensis* (MNHN-IM-2000-33216); Specimen illustrated by Inkhavilay *et al.*, 2017 (CUMZ 7041–7042); Two specimens of *A. thakhekensis* from Laos, and one specimen of *A. fuscolabris* from Vietnam (probably Dak Lak Province), in AC.

Amphidromus pervariabilis
Bavay & Dautzenberg, 1909 [“1908”]
(Plate 1, Figures F, G)

Amphidromus pervariabilis Bavay & Dautzenberg 1909 [“1908”], 1909a: 279–281, pl. 9, figs 1–10, pl. 10, figs. 1–8. Type locality: Ban-Lao, MuongKong, Pha-Long, Pac Kha. *Amphidromus pervariabilis* Bavay & Dautzenberg, 1909b: 246–247; Laidlaw & Solem, 1961: 527, 528; Inkhavilay *et al.*, 2017: 10, 13–14, figs. 5a–l. *Amphidromus* “*pervariabilis*” He & Zhou, 2017: 5, figs. 8–9. (Synonymized as *Amphidromus dautzenbergi* Fulton, 1899)

Differential Diagnosis. The resemblance between *A. pervariabilis* and *A. dautzenbergi* has been stated twice in previous studies (Laidlaw & Solem, 1961; and Inkhavilay *et al.*, 2017). He & Zhou, 2017 synonymized this species to *A. dautzenbergi* without explicitly given elucidation. Further, only two specimens of *A. pervariabilis* were illustrated; hence we are left to presume that this synonymy is solely on the basis of morphology. Although photographs of the syntypes of *A. pervariabilis* var. *lilacina* Bavay & Dautzenberg, 1909 [“1908”] and the holotype of *A. dautzenbergi* show an identity, because *A. pervariabilis* var. *lilacina* is not the nominotypical subspecies, its type specimens cannot be used to determine the synonymy of *A. pervariabilis* and *A. dautzenbergi* (ICZN 4th addition: Articles 45.6, 47, 61.2, 61.3). Both syntypes of the

nominotypical subspecies of *A. pervariabilis* (MNHM-IM-2000-2049) are different from the holotype of *A. dautzenbergi*. Unless additional supporting materials are collected, evidence to verify the synonymy is insufficient at this time.

Materials Examined. Syntypes of *Amphidromus pervariabilis* (MNHM-IM-2000-2049); one specimen of *A. pervariabilis* (AC); syntypes of *A. pervariabilis* var. *lilacina* (MNHM-IM-2000-2052); holotype of *A. dautzenbergi* (NHMUK 1899.12.18.38).

Amphidromus thanhhoaensis
Thach & Huber, 2016

Amphidromus thanhhoaensis Thach & Huber in Thach, 2016: 69–70, figs 35, 325–328. Type locality: Muong Lat District at the west of Thanh Hoa Province (North Vietnam).

Amphidromus (Syndromus) xiengkhaungensis Inkhavilay & Panha in Inkhavilay *et al.*, 2017: 35–37, figs. 13s–t. Type locality: Laos, limestone outcrop at Ban Nong Tang, Phou Kood District, Xieng Khaung, 19°30'59.2" N, 102°53'37.6" E, 1140 m asl.

Differential Diagnosis. The types of *A. xiengkhaungensis* are morphologically identical to *A. thanhhoaensis*, and no comparison is given in the description of *A. xiengkhaungensis*. The mountainous terrain with forest vegetation between the type localities of *A. xiengkhaungensis* and *A. thanhhoaensis* are approximately 200 km apart, which is unlikely to constitute an effective geographic barrier to dispersal for medium sized terrestrial snails (Goldberg & Severns, 1997). Since there is no persuasive evidence that suggests *A. xiengkhaungensis* is different from *A. thanhhoaensis*, I declare it to be in synonymy.

Materials Examined. Holotype of *A. thanhhoaensis* Thach & Huber, 2016 (NHMUK 20160299); Holotype and partial paratypes of *A. xiengkhaungensis* Inkhavilay & Panha, 2017 (CUMZ 7045-7046).

Amphidromus fengae Wang, new species
(Plate 2, Figures A-C)

Type Material. Holotype. Height 30.25 mm, width 12.45 mm, deposited in DLSM. Paratypes. Paratypes 1-4 in AC, dimensions: No. 1. Height 33.75 mm, width 12.50 mm; No. 2. Height 32.45 mm, width 14.15 mm; No. 3. Height 31.85 mm, width 12.40 mm; No. 4. Height 30.15 mm, width 12.65 mm.

Description. Shell sinistral; recorded height range 30.15-33.75 mm, average height 31.69 mm; width range 12.40-14.15 mm, average width 12.83 mm. Spire protracted, straight-sided; body whorls moderately inflated, upper extremity black; exterior surface yellowish-green to grayish-blue, the latter color is possibly the result of a color change after the death of the animal; adorned with oblique, parallel, beige streaks; subsutural area colored bright red as well as the umbilicus; aperture elongated ovate; peristome white or gray in color with black margin or completely black; columella vertical and outer lip flares outwards. Periostracum of the holotype is probably eroded, transparent corneous periostracum is whereas observed on paratype 3.

Habitat & Type Locality. All type specimens are collected as empty shells in monsoon rainforest during dry season in Kornsan District, Chaiyaphum Province, Thailand.

Differential Diagnosis. As compared to *Amphidromus anhdaoorum* Thach, 2017, this new species has the following distinguishing features: (1) Shell is bigger, average height

36.02 mm (Thach, 2017); (2) the protoconch is not tinted; (3) the subsutural area is pale yellowish in contrast to that of *A. fengae* n. sp. which is bright red; and, (4) *A. anhdaoorum* is, to date, only known from Dak Lak Province, Vietnam.

Comparison is also made to *A. dambriensis* Thach et Huber, 2016, *A. baolocensis* Thach et Huber, 2016, *A. ngocanhi* Thach, 2017, *A. yenlinhae* Thach et Huber, 2017, and *A. renkeri* Thach, 2018. All five of these species occur in Vietnam only, and all have different coloration on the subsutural area and peristome.

Etymology. This species is named in honor of Ms. Feng Xin Yue for her endearing spirit.

Amphidromus bozhii Wang, new species
(Plate 3, Figures A-B)

Type Material. Holotype. Height 74.10 mm, width 35.05 mm, deposited in DLSM. Paratypes. Paratypes 1-2 in AC. The dimensions of these paratypes are as follows: No. 1. Height 72.5 mm, width 33.8 mm; No. 2. Height 80.7 mm, width 34.5 mm.

Other Material Examined. One specimen measured 76.90 mm in height and 33.7 mm in width was inspected by the author but was lost during transportation.

Description. Shell colossal, average height 76.72 mm, average width 34.58 mm. Very solid, conical-tapering, dimorphic in coiling direction, sutures smooth, columellar straight, rima concealed, aperture somewhat flabellate; peristome white, expanded and reflected. Mostly purple; protoconch lacks coloration; middle and lower parts of body whorls dilated, upper part of whorls inclining and lighter-tinted; one broad but relatively shallow spiral channel occurs on the middle of the whorls - although

this channel is weak on the holotype compared to the paratypes it is readily recognized on the last half whorl. The channel and the sloping upper part of the whorls emphasize the space between them, forming a ridge; filmy corneous periostracum covers the exterior surface below the ridge.

Habitat & Type Locality. Phu Yen Province, Vietnam. This species dwells in monsoon rainforests.

Differential Diagnosis. This species is similar to *Amphidromus placostylus* Möllendorff, 1900 (Plate 3, Figure C). Nonetheless, *A. placostylus* does not exhibit purplish coloration which is always seen on *A. bozhii* n. sp., and a spiral channel is absent on *A. placostylus* (the outline of *A. placostylus* is very smooth). Additionally, the known locality of *A. placostylus* is Phuc Son (Bac Giang Province, Vietnam), approximately 600 km north-west of Phu Yen Province, therefore it is barely possible for these two species to surmount the geographic barrier because of the limited capability of dispersing of terrestrial gastropods.

A. naggsi Thach & Huber, 2014 and *A. ingens* Möllendorff, 1900 (Plate 3, Figures D, E) have smaller average shell height, more conspicuous surface structures and more variable coloration. The average shell height of *A. naggsi* is 55-65mm, and that of *A. ingens* is 69mm (Thach *et* Huber, 2014). Both species possess obvious horizontal channels on the shell's exterior and a variety of color forms, for example white and yellow.

Etymology. This species is named in honor of Mr. Lv Bo Zhi, a passionate enthusiast of shell collecting who vigorously volunteers his work as a disseminator of knowledge of malacology.

ACKNOWLEDGMENTS

We are sincerely thankful to Mr. Wang Jing Tao and Mrs. Zhang Miao, the parents of the senior author who were supportive of the author's work in many aspects. We are also thankful to Ms. Tian Ying from Da Lian Shell Museum who accepted the type materials provided by the senior author as well as several anonymous professionals whose comments that were propounded online helped the authors amend the contents of this article. Mr. Wei Peng and Mr. Lv Yi Feng provided valuable information regarding the identification of specimens.

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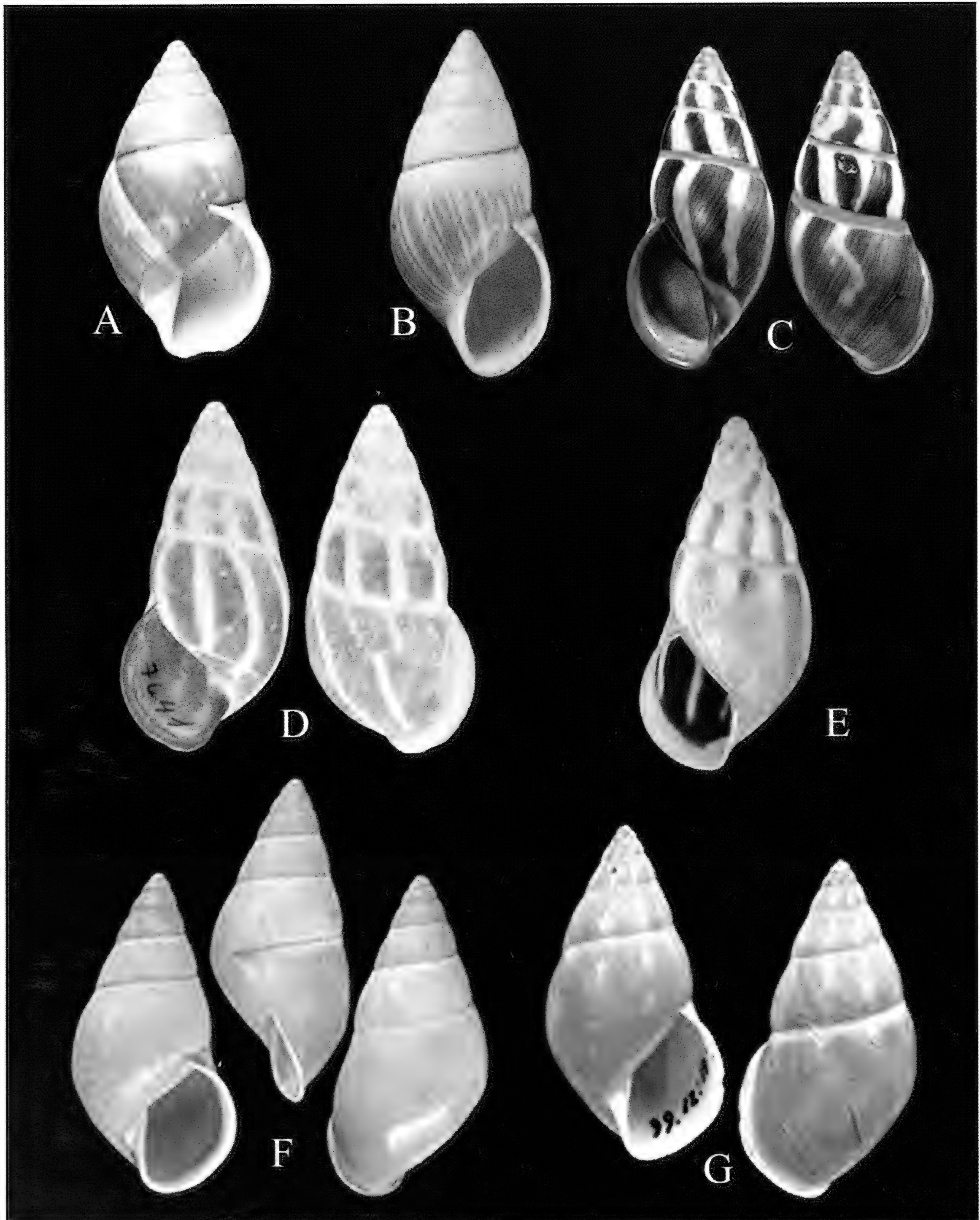



Plate 1. Figure A = Holotype of *Amphidromus richgoldbergi* (FMNH 381986), aperture view. B = Syntype of *A. givenchyi* (MNHN-IM-2000-2035), aperture view. C = Atypical color form of *A. thakhekensis* (CUMZ 7041), collected in Ban Phon, Sekong Province, Laos. D = Holotype of *A. fuscolabris* (SMF 7641). E = Surmised specimen of *A. fuscolabris* (AC), possibly collected in Dak Lak Province, Vietnam. F = Syntype of *A. pervariabilis linacina* (MNHM-IM-2000-2052). G = Holotype of *A. dautzenbergi* (NHMUK 1899.12.18.38). Figures 1, 3-4 are excerpted respectively from Inkhavilay *et al.* (2019) and Inkhavilay *et al.* (2017).

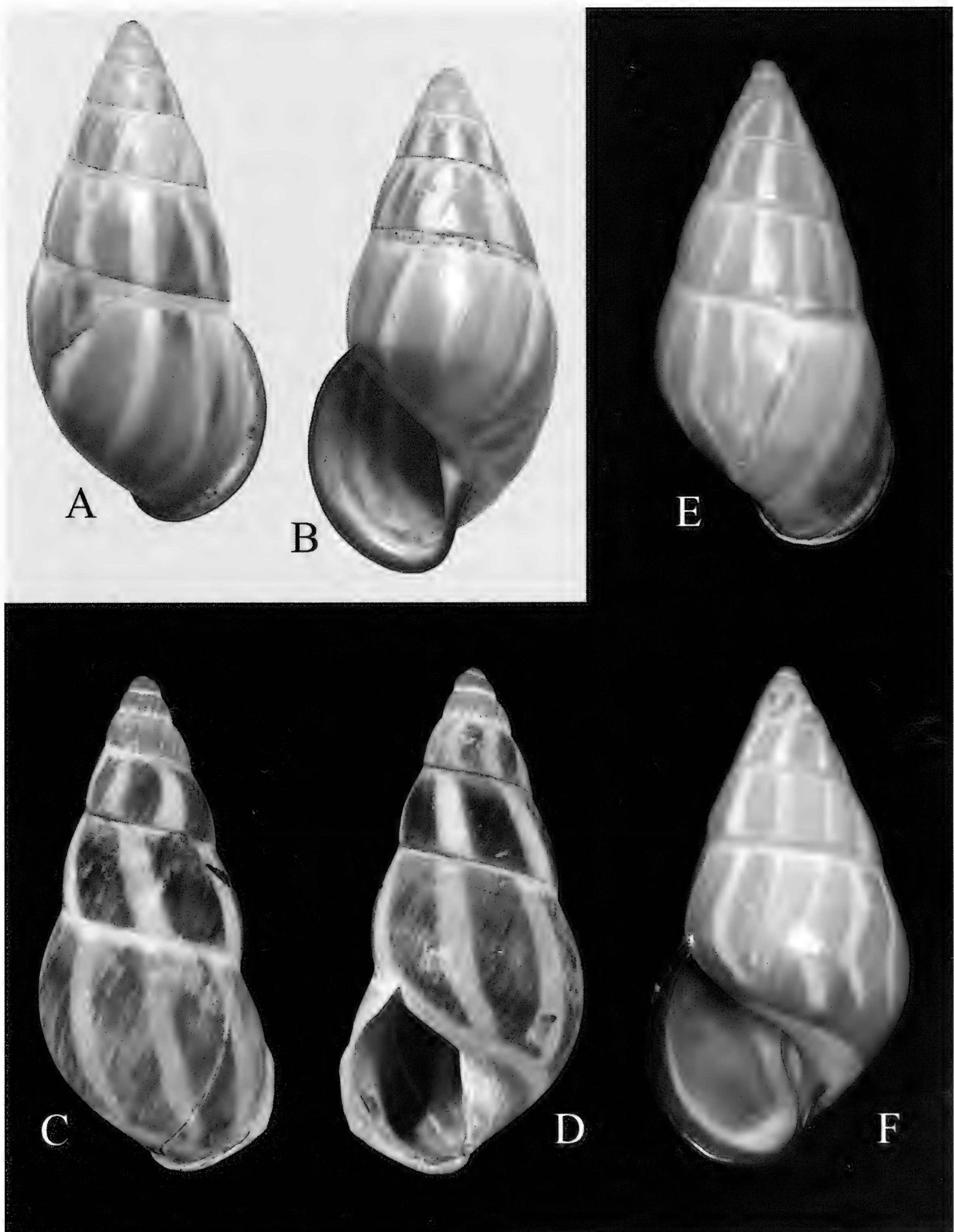


Plate 2. Figures A-B = Holotype of *Amphidromus fengae* n. sp. C-D = Holotype of *A. yenlinhae*, photo of MNHN. E-F = *A. anhdaoorum*.

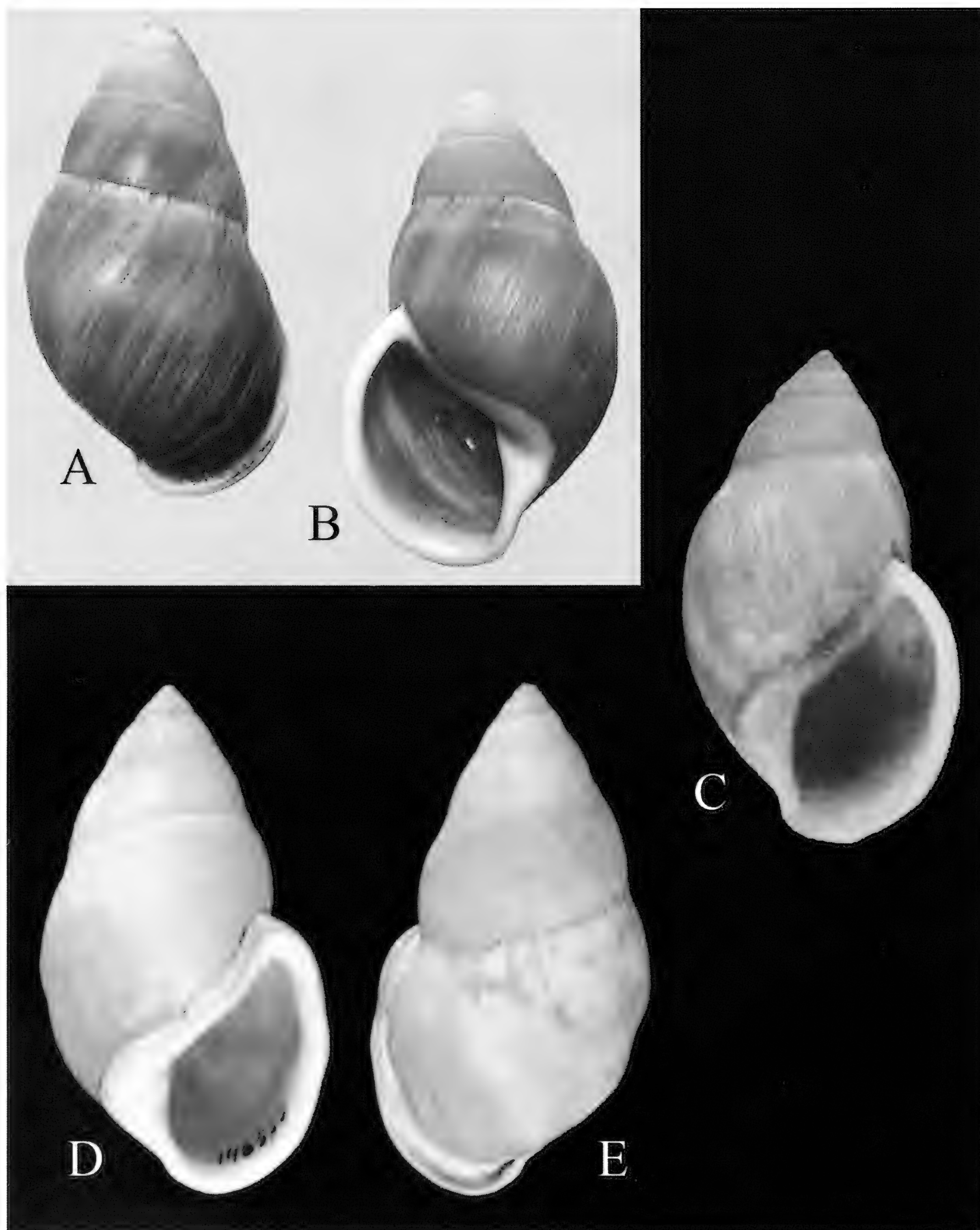


Plate 3. Figures A-B = Holotype of *Amphidromus bozhii*. C = Holotype of *A. placostylus*, extracted from Thach, 2017. D-E = Cotype of *A. ingens* (UMMZ 146553).

A new subspecies of *Asperitas bimaensis* (Mousson, 1849) from western Sumbawa, West Nusa Tenggara, Indonesia

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ABSTRACT This paper describes a new subspecies of *Asperitas bimaensis* (Mousson, 1849) from Alas District, western Sumbawa in West Nusa Tenggara, Indonesia. Shell coloration, pattern, sculpture, shape and periostracum separate it from the other subspecies of *A. bimaensis*, and a similar looking relative from western Sumbawa.

KEY WORDS Dyakiidae, *Asperitas bimaensis abbasianus*, Alas District, Sumbawa, Indonesia

INTRODUCTION

During a 2006 trip to western Sumbawa, John Abbas and locals collected colourful specimens of *Asperitas* Gude, 1911 on various crop trees and plants on the lower volcanic slopes of the north western-part of Olet Sangenges, Alas District. On several later trips, John Abbas and locals found them at several neighbouring sites, c. 3 km east of Alas. Initially identified as *Asperitas* (cf.) *trochus* (Müller, 1774), and later circulated by others as *Asperitas trochus polymorpha* (E.A. Smith, 1897) and *Asperitas trochus tjendanae* Rensch, 1932. After a review of type specimens of *Asperitas* known to occur on Sumbawa, I consider these snails as relatives of *Asperitas bimaensis* (Mousson, 1849), and described herein as a new subspecies.

Materials and Methods

Eight shells make up the type series, the holotype and seven paratypes (1 NHMUK, 2 MNHN and 4 JP or JA), plus four additional specimens (JP). Photography credits are as indicated below each image. The species description was determined from the shell

morphology of dry empty shells obtained by John Abbas. Comparative material comprised of shells from the author's private collection and images found on the Internet. Relative shell sizes (width) for the genus *Asperitas* mentioned are as follows: small < 25 mm, medium 25-40 mm and large > 40 mm.

Shells were measured using digital Vernier callipers (0.01 mm resolution). Shell sculpture was examined under low magnification (10x) using a jeweler's loupe. Whorl count includes the apex and counted precise to 0.125 ($\frac{1}{8}$) whorl. Shell weight was measured in grams (g) using a pocket-sized electronic scale (capacity 300 g x 0.01 g). 'Paries' (adj. parietal) refers to the 'inner apertural wall' and 'palatum' (adj. palatal) refers to the 'outer apertural wall'.

Taxonomic remarks

The full genus status and family group placement of *Asperitas* follows that of Rensch (1931 & 1932) and Hausdorf (1995), and the accepted species follows that of Dharma (2005 & 2012).

Abbreviations used for museums and private collections:

MNHN:	Muséum national d'Histoire naturelle, Paris, France
NHMUK:	Natural History Museum, London, England, United Kingdom
ZMB:	specimen label code at Museum für Naturkunde, Berlin, Germany; previously known as Zoologisches Museum Berlin
JA:	John Abbas collection
JP:	Jeff Parsons collection

Abbreviations for shell morphometry, shell coiling and other:

D:	shell width (abbreviation for 'diameter' as per literature usage)
H:	shell height
H/D:	shell height/shell width ratio
N:	whorl count
W:	shell weight
JP	data, observations, comments or other by Jeff Parsons

SYSTEMATICS

Family: Dyakiidae Gude and Woodward, 1921

Genus: *Asperitas* Gude, 1911

Types: *Xestina rugosissima* Möllendorff, 1903

Asperitas bimaensis abbasianus Parsons,
new subspecies (Figure 1 and Plate 1)

Description. (Holotype) High-spired globose shell of medium-size, fairly solid and translucent. Apex obtuse, very slightly exserted and suture impressed. Surface shiny; first half whorl subplicatulate, rest of protoconch smooth with an infrasutural row of very short threadlets; teleoconch with faint spiral microstriations overlain by crowded microthreads and intermixed with close-set pliculae on the last whorl, weaker on base and distant behind lip. Whorls $5\frac{3}{4}$, not descending in front, top and base convex; ultimate's periphery rounded, faintly angular near lip terminus. Shell albous with four hazel bands on the last whorl: infrasutural, superior, peripheral and inferior, first and third slightly darker. Bands emerge faintly on antepenult and intensify toward lip; width ratio c. 1:4:4:8. Periostracum dichroic: viridian green on lower spire, worn away

apically and faint buff on last whorl. Aperture roundly lunate, oblique. A colourless film coats viridian green periostracum on the paries. Glaze on palatum slightly thicker, faintly whitened and translucent, showing external pattern. Outer lip simple, thickened and sub-labiate basally; albous, edged with pale buff. Columella albous, cuneate, thick and slightly abaxial. Columellar margin briefly dilated and reflexed at its insertion, almost occluding a very narrow umbilicus.

Type Material. Eight shells from the type locality. Holotype (NHMUK 20160362/1, Figure 1) H 28.60 mm, D 30.77 mm, H/D 0.93, N 5.75 & W 2.19 g. Paratypes 1-7, 3 adults + 2 sub-adults (paratypes 3 & 4) [1 NHMUK 20160362/2; 2 MNHN IM-2012-2799a; 3 MNHN IM-2012-2799a; 4-7 JA] (paratype 7 Plate 1, Figure 3 and paratype 4 Plate 1, Figure 4). H 22.60-34.70 (av. 28.42) mm, D 25.55-37.59 (av. 30.41) mm, H/D 0.88-1.03 (av. 0.93), N 5.0-6.0 (av. 5.61) & W 0.65-2.85 (av. 1.65) g.

Other Material Examined. Four shells from type locality, three adults (Plate 1, Figure 5) + one sub-adult (JP) and digital images of shells from the first colony discovered (Plate 1,

Figures 6-13). H 22.38-31.84 (av. 27.88) mm, D 26.37-31.71 (av. 29.32) mm, H/D 0.85-1.00 (av. 0.95), N 5.125-6.0 (av. 5.50) & W 0.61-2.10 (av. 1.54) g (4 shells, JP).

Type Locality. Lower volcanic peaks (below 600 m asl.) on the north western-part of Olet Sangenges c. 3 km east of Alas, Alas District, NW Sumbawa in West Nusa Tenggara, Indonesia; c. 8°30'S 117°E.

Distribution. NW part of Olet Sangenges, NW Sumbawa.

Ecology/Habitat. Collected by John Abbas and locals on the leaves and stems of various short herbaceous or woody plants in cultivated areas and nearby Monsoon forest. Locally common and considered pests by locals.

External Features of Animal. Not known.

Soft parts. Not available for study.

Etymology. Named in honour of John Abbas and his family for supplying the type material.

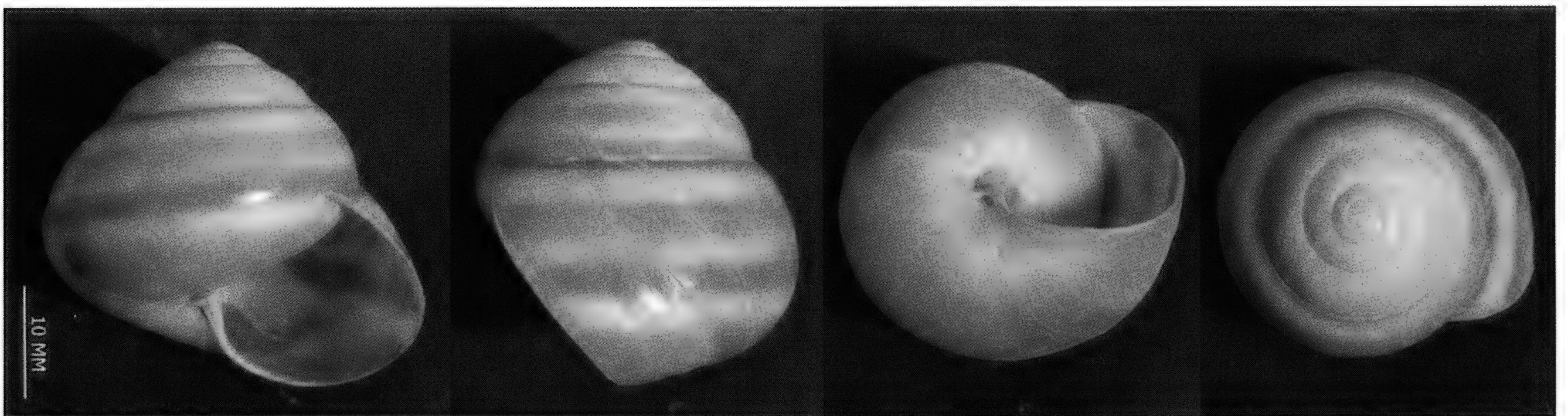


Figure 1. Holotype of *Asperitas bimaensis abbasianus* n. ssp. NHMUK 20160362/1 [photos: JP]

Shell Variation.

Simply described as a polychromatic subspecies. Mature shells have thickened lips, sublabbiate or not, and may have a pale buff edge to only the lip, or that extends onto the columella and parietal callus margin. Variation in band width is minor. The basal band may be a little wider and almost reaches the umbilicus. The infrasutural (ISB) and peripheral bands (PB) are sometimes composed of two narrower bands, the primary band brown and the other forming a grey border. Sometimes the superior (SB) band is wider than the peripheral (PB) band. Light shells strongly translucent, almost transparent and other shells moderately translucent. Exterior colour of the last whorl shows through to the interior (Plate 1, Figures 6-8). A white sutural

thread is very rarely present, typically on the last whorl (Plate 1, Figures 6, 9 & 10). Sculpture as per holotype or finer, no pliculae on last whorl.

Shells from the type locality rarely show a change in ground colour, such as pink spire whorls changing to white on last whorl. The periostracum is dichroic, being green (viridian, dark sulphate or bright guinea) on spire whorls changing generally to faint buff, rarely antimony yellow on the last whorl (Plate 1, Figures 1, 4 & 5), or sometimes to pale pinkish buff on penult or last whorl. Ground colour change commonly occurs in shells from the first colony discovered (Plate 1, Figures 6-13, except 11). Although all images studied show bleached specimens, one shell I own has a green stained

paries. This suggests they too have green periostracum on the spire, but it does not stain the shell surface as it does in shells from the type locality.

Band colour is variable with the ISB & PB slightly darker than the other bands, of a different tone or hue. The type locality shells are often white and tend to have orange - or reddish-brown ISB & PB with the other two bands paler (Plate 1, Figure 2) or flesh-pink, or all four bands same-coloured (Plate 1, Figure 3), or rarely pattern less (Plate 1, Figure 5). The ISB & PB bands on the other shells are orange-, reddish- or blackish-brown or black, and the other two bands of the same tone (Plate 1, Figure 11), paler (Plate 1, Figures 8 & 12) or dark vinaceous (Plate 1, Figure 13). Their shells commonly have white or pink spire whorls staying the same or changing on last or last half whorl, and commonly lack bands (Plate 1, Figures 6, 7, 9 & 10). A white spire changes to carnelian red, purplish vinaceous or blackish. A pink (old rose, eosine or jasper) spire changes to white, pompeian red or blackish. Rarely the shell is coral red with or without white early whorls.

DISCUSSION

All the species discussed here tend to have similar sized shells. *A. bimaensis bimaensis* (Mousson, 1849) (Plate 2, Figure 14) differs in having an obtusely conoid shell with a somewhat flat base and rounded-trapezoid aperture. Either plain white or with faint grey spiral bands (SB and PB) with pale buff periostracum. Sculpture slightly coarser, especially at the suture of the last whorl.

The new subspecies is most similar to *A. bimaensis halata* (Mousson, 1849) (Plate 2, Figures 15-17), which differs in often having a flatter shell with a more open, slightly wider

umbilicus and transverse sculpture not weakened on base. Shell white with a green or bluish-green periostracum throughout or changing to light buff on the last whorl, or light buff throughout. It may have a similar four-banded pattern, except all the bands are pinkish brown, or the ISB and PB are brown and the other two pinkish brown. Differs in having two other banding patterns, two-banded (ISB and PB) or three-banded (ISB, SB and PB), or lacks bands. Also the ISB is more variable, brown or green and distinct or faint on dark-banded shells; and faint or absent (*e.g.* 2-banded syntype) on pale-banded shells *vs.* present and green or absent on patternless shells

A. bimaensis subpolita (E.A. Smith, 1897) (Plate 2, Figure 18) has a different shaped shell, turbinate or conoid-globose, sub-polished with a depressed-convex last whorl. Spiral sculpture on spire coarser and suture white or luteous margined. Spire purplish, last whorl pale chestnut and interior white or livid-fuscous toward lip. Periostracum differs by showing two or three colour changes: whole spire viridescent or green on penult green-cerulean and green above, changing to pale buff on the last whorl. Similar in mature shells having a limbate aperture, except the external and internal margins of aperture, and columella are fuscous-tinted.

A. bimaensis cochlostyloides (Schepman, 1892) (Plate 2, Figure 19) differs by having a dull, globosely conical and often heavy shell with flatter whorls, the last descending a little in front. Aperture rounded-rhomboid and suture deep on lower whorls, white margined. Differs from all other subspecies in the "biangular character" of the last whorl, a rounded angle near the suture and one towards the base. Similar in typically having a dichroic periostracum, changing colour on the last whorl (*e.g.* green to straw), but it is hydrophanous,

commonly deciduous and sometimes of one colour (green or blue green). It has different ground colour changes on last whorl (see Schepman, 1892 for details), orange, yellow or green vs. white on upper whorls. Palatum bright orange, citron yellow or white and not always the same as the exterior.

A. bimaensis soembaensis (Schepman, 1892) (Plate 2, Figure 20) differs in having a more depressed shell, typically purplish or brown, but also white, pinkish-white or yellow. Periostracum is deciduous, yellowish or olive and almost complete or patchy on the last whorl. Suture margined with opaque white and periphery of last whorl is subangular, often marked by a very narrow white band. Both white bands are usually faint and only visible if wetted. No other bands present and interior shows external colour, or is livid in dark shells.

A. bimaensis liei Thach, 2018 (Plate 2, Figure 21) differs in having a larger, thicker brown depressed globose shell with a stepped spire, inflated last whorl and wider, more open umbilicus. It has a similar staining on the external margin of its lip, and possibly the columella and parietal margin, except it tends to thicken the latter margins in a gerontic fashion. Periostracum is green on early whorls changing to olive-green.

A. everetti notabilis (Rensch, 1930) (Plate 2, Figures 22–25) differs in having a deciduous periostracum, which is green on spire whorls of adult shells and yellow-brown on the last whorl. Sculpture consists of coarser close-set pliculae crossed by spiral striae, coarser on the last whorl creating a subgranulose appearance, and transverse sculpture not weakened on base. Three patternless shells: holotype is pink changing to white behind lip, small shell is flesh-coloured and large shell is pink changing to white on last whorl. A third paratype is a

three-banded shell with a ratio of c. 2:2:9 mm; shell is pale pink with purplish bands. All four lack an infrasutural band.

Final Comments and Conclusions.

Current data suggests the three subspecies of *Asperitas bimaensis* occur separately on Sumbawa. The new subspecies occurs in the western part of Sumbawa, *Asperitas bimaensis halata* in central Dompu Regency, and the nominate subspecies near Kota Bima in Bima Regency, with no overlap in their territories.

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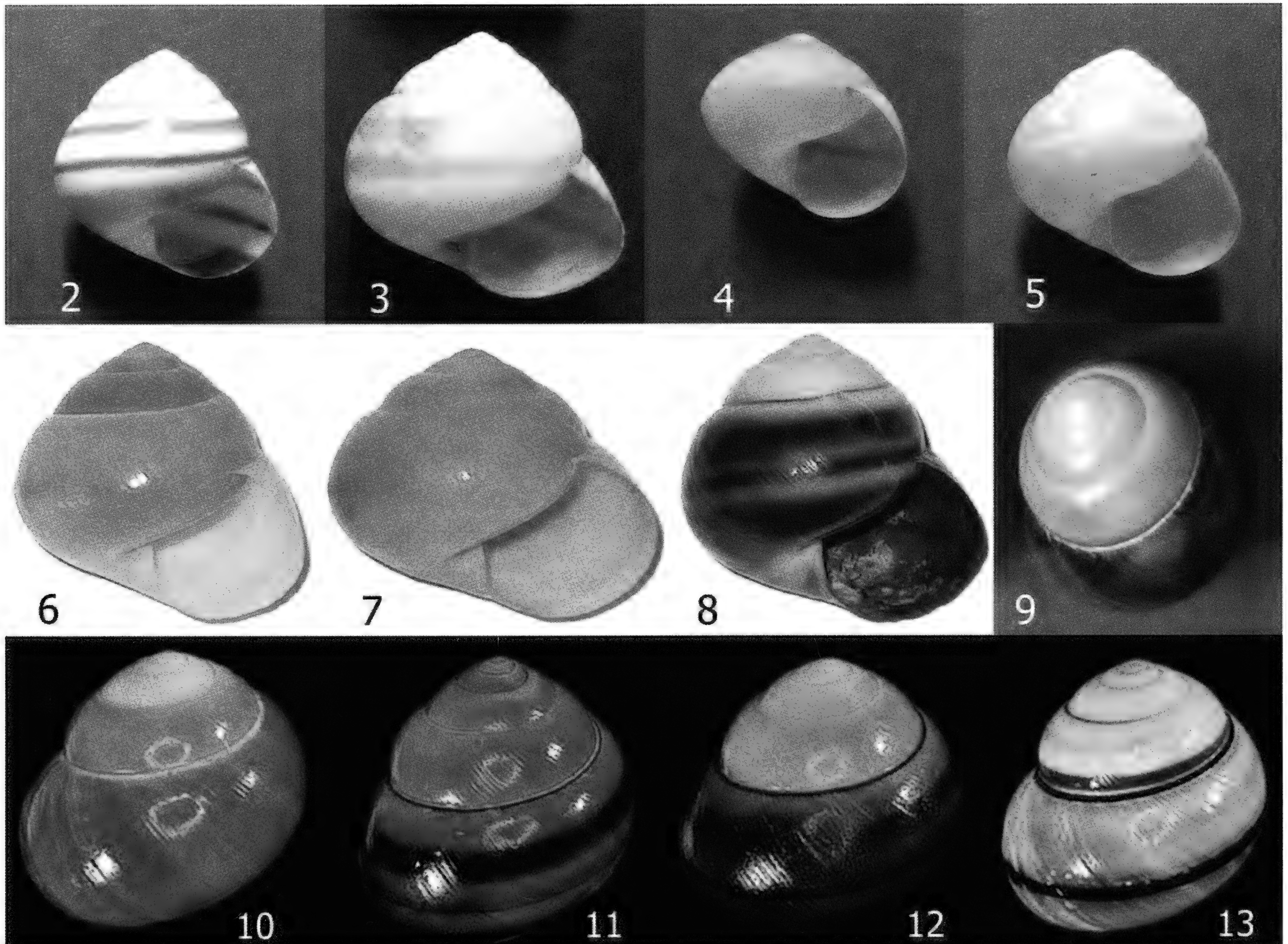


Plate 1: *Asperitas bimaensis abbasianus* n. ssp., with figure numbers listed below.

First row, Figure 2. paratype 1 NHMUK 20160362/2, **Figure 3.** paratype 4 (JA), **Figure 4.** paratype 7 (JA), **Figure 5.** non-type shell (JP) [Figures 2-3 bleached, Figure 4 sub-adult].

Second & third rows, Figures 6-13 non-type shells from the first colony discovered [all bleached].

[Photographic credits: Figures. 2-5 JP; Figures 6-8 Gallego, 2019; Figure 9 John Abbas; Figures 10-13 J & M Coltro, 2017]

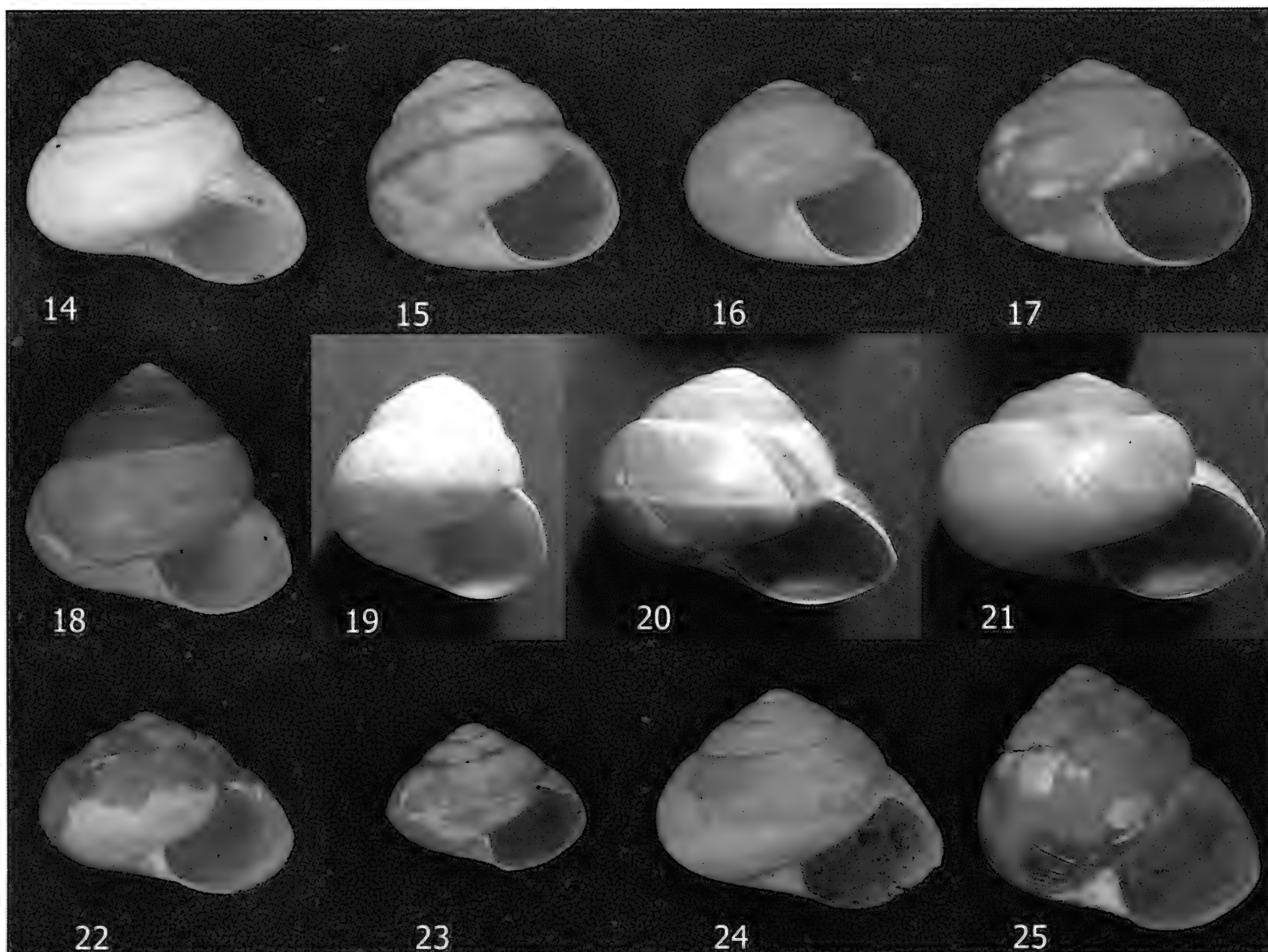


Plate 2: Relatives of *Asperitas bimaensis abbasianus* n. ssp., with figure numbers listed below.

First row, Figure 14. *A. bimaensis bimaensis* Bima, E Sumbawa ZMB.Mol.47475; **Figures 15-17.** *A. bim. halata* Dompu, Cen. Sumbawa ZMB.Mol.75127.

Second row, Figure 18. *A. bim. subpolita* south Flores ZMB.Mol.49814; **Figure 19.** *A. bim. cochlostyloides* E Sumba (JP); **Figure 20.** *A. bim. soembaensis* Kehutanan, W Sumba (JP); **Figure 21.** *A. bim. liei* Cen. Sumba (JP).

Third row, *A. everetti notabilis* Batu Dulang, W Sumbawa (800-1200 m asl.), **Figure 22.** holotype ZMB.Mol.75124, **Figures 23-25.** paratypes ZMB.Mol.75125a.

[Photographic credits: Figures 14-18 Museum für Naturkunde, 2019a-c; Figures 19-21 JP; Figures 22-25 Museum für Naturkunde, 2019d].

A new species of *Papuina* von Martens, 1860 from Nabire, Papua, Indonesia

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ABSTRACT This paper describes a new species of *Papuina* von Martens, 1860 from forest near the Nabire River, SE Cenderawasih (Geelvnik) Bay in Papua Province, Indonesia. Shell periphery, pattern, sculpture, apertural features and coloration separate it from relatives with shells of similar size and shape.

KEY WORDS *Papuina*, *Papuina abbasianus*, Nabire River, Papua, Indonesia

INTRODUCTION

March 2019, John Abbas sent me images of a *Papuina* von Martens, 1860 that he could not identify from Papua Province, Indonesia. A local collected these snails for John in native forest near the Nabire River, in the southeastern part of Cenderawasih (Geelvnik) Bay. After a short discussion, we decided it could be an undescribed species, and John sent two empty specimens to me for further study. A study of other *Papuina* from the same region and the Aru Islands, found they are conchologically separable from the other species, and described herein as a new species.

Materials and Methods

Three shells make up the type series, the holotype and two paratypes (1 TT and 1 JA). Photography credits are as indicated below each

image. The species description was determined from the shell morphology of dry empty shells obtained by John Abbas. Comparative material comprised of shells from the author's private collection and images of museum types or specimen shells. Relative shell sizes (height) for the coniform genus *Papuina* mentioned are as follows: small < 20 mm, medium 20–35 mm and large > 35 mm.

Shells were measured using digital Vernier callipers (0.01 mm resolution), sculpture examined under low magnification (10x) using a jeweller's loupe, and weighed using a pocket-sized electronic scale (capacity 300 g x 0.01 g). Whorl count includes the apex and counted precise to 0.125 ($\frac{1}{8}$) whorl. 'Paries' (adj. parietal) refers to the 'inner apertural wall' and 'palatum' (adj. palatal) refers to the 'outer apertural wall'.

Abbreviations for shell morphometry, shell coiling and other:

D:	shell width (abbreviation for 'diameter' as per literature usage)
H:	shell height
H/D:	shell height/shell width ratio
N:	whorl count
W:	shell weight
JP	data, observations, comments or other by Jeff Parsons

Abbreviations used for museums and private collections:

NBC:	Naturalis Biodiversity Center, Leiden, Netherlands
NHMUK:	Natural History Museum, London, England, United Kingdom
RMNH:	NBC specimen label code, ex-Rijksmuseum van Natuurlijke Historie
ZMA:	NBC specimen label code, ex-Zoological Museum Amsterdam
ZMB:	specimen label code at Museum für Naturkunde, Berlin, Germany; previously known as Zoologisches Museum Berlin
JA:	John Abbas collection
JP:	Jeff Parsons collection
TT:	Tejas Thackeray collection

SYSTEMATICS

Family: Camaenidae Pilsbry, 1895
 Subfamily: Hadrinae Iredale, 1937
 Genus: *Papuina* von Martens, 1860
 Type: *Helix lituus* Lesson, 1831

Papuina abbasianus Parsons, new species
 (Plate 1, Figures 1-8)

Description. (Holotype) Medium-sized coniform shell, semi-obtect umbilicate, solid and translucent. Spire high conical; apex obtuse, subexsert. Surface shiny, protoconch smooth; teleoconch with spiral striations overlain by growth lines and threads; last whorl plicatulate, the pliculae weaker and spiral striations worn on base. A trace of buff periostracum on the last whorl. Whorls 7, regularly increasing, hardly descending in front and early ones convex, flattened toward the last; base depressed, slightly convex. Teleoconch's periphery with a crenulated filiform carina (carinula), obsolete on penult, and subangular on last whorl. Suture impressed, thread-margined on post-apical spire whorls. Shell vinaceous cinnamon with a narrow infrasutural band, white on lower whorls, fading and greyed apically; and a narrow castaneous suprapерipheral band, fading-in on the penult and almost reaches the lip's edge. Aperture subrhombic-lunar, margins sub-convergent, broader than high and subeffuse

peripherally. Parietal callus only a transparent orange cinnamon glaze, slightly darker than the base. Palatum whitened and translucent, the external coloration showing through. Outer lip white, subcrassate; upper margin arched forward and expanded peripherally, edge simple; lower margin expanded, sub-reflexed, rounded below periphery and straightened basally. Columella white, incrassate, suberect and adaxial, forming a right angle with the lip. Columellar margin sub-arcuate and broadly dilated, partially concealing a narrow umbilicus.

Type Material. Three adult shells from the type locality. Holotype (NHMUK 20190604, Plate 1, Figures 1-6) H 34.29 mm, D 31.90 mm, H/D 1.07, N 6.875 & W 1.97 g. Paratype 1 (TT, Plate 1, Figure 7) D 33.3 mm, H/D 0.93. Paratype 2 (JA, Plate 1, Figure 8) D 33.49 mm, H/D 1.10.

Measurements. (Three types) H 31.1-34.29 (av. 32.96) mm, D 30.58-33.30 (av. 31.93) mm, H/D 0.93-1.10 (av. 1.03), N 6.75-7.125 (av. 6.917) & W 1-1.97 (av. 1.42) g.

Type Locality. Forested hills near the Nabire River, Nabire Regency, southeastern Cenderawasih (Geelvnik) Bay in Papua Province, Indonesia.

Distribution. Currently known only from Nabire Regency .

Ecology/Habitat. Unknown.

External Features of Animal. Unknown.

Soft Parts. Not available for study.

Etymology. Named in honour of John Abbas and his family for supplying the type material.

Note. Currently only three specimens known.

Shell Variation. Ground colour vinaceous cinnamon (holotype = H; Plate 1, Figures 1-6), pinkish buff (paratype 1 = P1; Plate 1, Figure 7) or light ochraceous-salmon (paratype 2 = P2; Plate 1, Figure 8). All whorls of the same colour (H and P1), or early whorls different to later whorls, dark brown (P2) and the infrasutural band on the former is white on lower whorls, faded above and greyed apically; and on the latter it is greyish white, faint on later whorls; and in transmitted light, opaque or not respectively. Last whorl hardly or scarcely descends in front. Sculpture on the last whorl as per holotype, or smoother with close-set growth threads and no pliculae (P2).

Supraperipheral band almost reaches the lip's edge; either castaneous and very narrow, emerging faintly on the antepenult (H and P1); or nigro-castaneous, wider and emerges on the fourth whorl (P2), and width on the last whorl 0.6 mm vs. 2 mm respectively. In the multi-banded form (P2) bands develop on the third whorl, 4 narrow castaneous bands on top, the lowest just above the supraperipheral band; and 3 castaneous lines on the base near the umbilicus, upper one thinner & faint. Width of bands as follows: top 0.4, 0.6, 0.6, 0.4 mm; middle 2 mm; and lower bands 0.1, 0.4, 0.3 mm.

Aperture subrhombic-lunar, broader than high (H and P1) or subtrigonal-lunar, less wide, taller & rounder than in holotype (P2); and effuse or sub-effuse peripherally, forming a wide, shallow papuinoid notch or weakly indicated respectively. Parietal callus slightly darker than the base, orange cinnamon (H), cinnamon buff (P1) or ochraceous buff (P2), and the palatum more or less whitened. Outer lip obtusely pointed at the periphery (P2), rounded (H) or intermediate (P1); lip edge recurved at the periphery (P2) or not (H and P1). Lower lip margin straightened basally (H and P1) or not (P2), and columellar margin partially conceals (H and P2) or almost seals the umbilicus (P1).

DISCUSSION

I consider the following species as relatives of *P. abbasianus* n. sp. based on shared conchological features.

Papuina pileus (Müller, 1774) is similar in having a white lip and a single- or multi-banded shell (Plate 1, Figures 9-10). Shells are of equal size or smaller with an equal to greater H/D ratio, and slightly fewer whorls, lower ones more convex. Last whorl is scarcely or not descending in front and obtusely subcarinated on the lower edge of the periphery. Aperture is smaller, more oblique, of a different shape and peripheral effusion negligible or very slight. Parietal callus is light buff, of a different colour to base. Sculpture much finer and shells are differently coloured. Palatum shows the external pattern and coloration, except the coloured upper surface is brighter.

Protoconch unicoloured, generally dark purple or reddish, rarely yellowish or cream coloured. Suture dark lined (dark brown or grey) on lower whorls. Brown bands on upper surface vary in number, tone and width. All shells have a very wide basal zone, usually dark brown (Plate 1,

Figure 9), or sometimes pinkish- (Plate 1, Figure 10) or yellow brown, its colour entering the umbilicus or not. Upper surface is uniform white (Plate 1, Figure 9), cream-coloured, pinkish- (Plate 1, Figure 10) or pale yellowish-brown with or without brown spiral bands and lines. The coloured upper surface commonly has paler and darker oblique streaks; bordered above and below by opaque white bands, upper one thin (subsutural) and lower one narrow (infraperipheral), absent on white shells.

Papuina astridae Dupuis, 1931 is the most like *P. abbasianus* n. sp. in appearance. Columella, columellar margin and lip are the same, except mauve (Plate 1, Figure 11) or white (Plate 1, Figure 12). Parietal callus is golden brown (Plate 1, fig. 11) or slightly darker than the ground colour (Plate 1, Figure 12). The suprapерipheral band is chestnut or chocolate-brown. Differs in the suture is not white-margined, top of whorls almost flat and the base flattened toward an angular periphery, and apertural effusion is less distinct. Sculpture is different, protoconch very slightly granular and lower whorls plicate, the plicae thinner but not weakened on the base.

Papuina euchroes (Pfeiffer, 1854) (Plate 1, Figure 13) has a slightly larger and rather solid shell with the lower whorls and base more convex, and differently coloured. Pfeiffer described the last whorl as “reddish-fulvous” and since then it has lost most of its periostracum to reveal a vinaceous buff colour. Spire is lilaceous-rose, paler apically. It has a wider suprapерipheral band and a second thinner, pale chestnut band just below a wide, brighter white infrasutural band that emerges mottled on the antepenult. The paries is marked with a diffuse brown circumcolumellar band, not exiting the aperture, and a narrower brown band borders the palatum. Aperture is more oblique, less broad and of a different shape with slight

peripheral effusion. Parietal callus is light buff and the palatum is griseous-albous. Outer lip and columellar margin are violet tinted and callused, forming a lump on the basal margin. Back of lip brown, bordered by a hazel stripe that continues into the umbilicus. Inner edge of columella white and not callused, forming an oblique angle with the basal margin. Sculpture different, very minutely granulate and last whorl smoother with close-set growth threads.

Papuina lenta (Pfeiffer, 1854) (Plate 1, Figure 14) differs in having a slightly smaller and thinner shell with a much finer sculpture. It is differently coloured, griseous-carneous or reddish-carneous with opaque dull whitish bands. Aperture less broad, subtrigonal-lunar with slight peripheral effusion and same-coloured within. Columella, columellar margin and lip are thinner and violaceous-blackish; lip sub-reflexed.

The original description says *Papuina lenta* var. *pseudeuchroes* Vernhout, 1913 (Plate 1, Figure 15) resembles *P. lenta* but is coloured more like *P. euchroes*, except it has a slightly larger yet equally solid shell. Compared to *P. abbasianus* n. sp. it has a similar sculpture, aperture shape and size. Differs in having a more oblique basal margin and a callused greyish-white palatum, weakly showing the external pattern. Outer lip, columella and columellar margin are more expanded, thicker and lead-coloured, edged with dark brown externally. Shell rufous with a brighter white infrasutural band, which widens toward the lip, a dark brown circumumbilical band and a wider chestnut suprapерipheral band, bordered on both sides by narrower white bands.

Papuina leucorhaphé von Möllendorff, 1899 (Plate 1, Figure 16) has a similar multiple-band pattern of a narrow fuscous suprapерipheral band with thinner chestnut bands and lines above, and chestnut lines on the base. Differs in

having a less solid shell with a much finer sculpture and corneous periostracum, slightly more convex upper surface and the base is more convex just below a rounded periphery. Shell greyish white with a brighter white infrasutural band, widening toward the lip. Aperture less broad, of a different shape with slight peripheral effusion, a thinner colourless parietal callus and a white palatum that shows the external bands. Outer lip, columella and columellar margin blackish brown, thinner and slightly less expanded.

The similarities and differences in two specific shell features for all species are summarized as follows.

Supraperipheral band and other bands partially extend onto, cross or fall short of the back of the lip: (1) Extend onto back of the lip, but do not reach its edge - *P. abbasianus* n. sp.; (2) cross back of the lip and reach its edge - *leucorhapse*; (3) fall short of the lip - *P. pileus*, *P. astridae*, *P. euchroes*, *P. lenta* and *P. lenta* var. *pseudeuchroes*.

Shell periphery with or without a crenulated carinula present, forming a thread-margined suture and fading away on the antepenult or penult: (1) Fades away on penult - *P. abbasianus* n. sp., *P. lenta* var. *pseudeuchroes*; (2) fades away on antepenult - *P. pileus*, *P. astridae*, *P. euchroes*; (3) absent on *P. leucorhapse*. Since images of the types for *P. lenta* are currently unavailable, it is unknown if a crenulated carinula is present on post-apical whorls or not.

ACKNOWLEDGMENTS

I thank John Abbas for supplying the type material and Andy Tan for images of paratype 1 and thank those who supplied specimens of *P.*

pileus. I also owe many thanks to Jonathan Ablett, Curator (of Non-Marine Mollusca and Cephalopoda, Division of Invertebrates, Zoology Department, NHMUK), for assistance in depositing type material of *Papuina abbasianus* n. sp.

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- Museum für Naturkunde. 2019b.** '*Papuina leucorhapse*,' Image: Probable Type ZMB.Mol.51102. Available from the Global Biodiversity Information Facility online database. [Accessed: 20 April 2019] http://gbif.naturkundemuseum-berlin.de/CDV2018/Mollusken/Arten/ZMB_Mol_51102_3.jpg
- Pfeiffer, L 1848 (1840-50).** 'Die Schnirkelschnecken (Gattung *Helix*),' In HC Küster et al (Eds.), *Systematisches Conchylien-Cabinet von Martini und Chemnitz II*, 1 (12) [(1)]. Bauer und Raspe, Nürnberg (Nuremberg): V-XV, 1-400, pls. 1-66, 12*. *Helix pileus* var. pp. 156-157, pl. 40, Fig. 5.

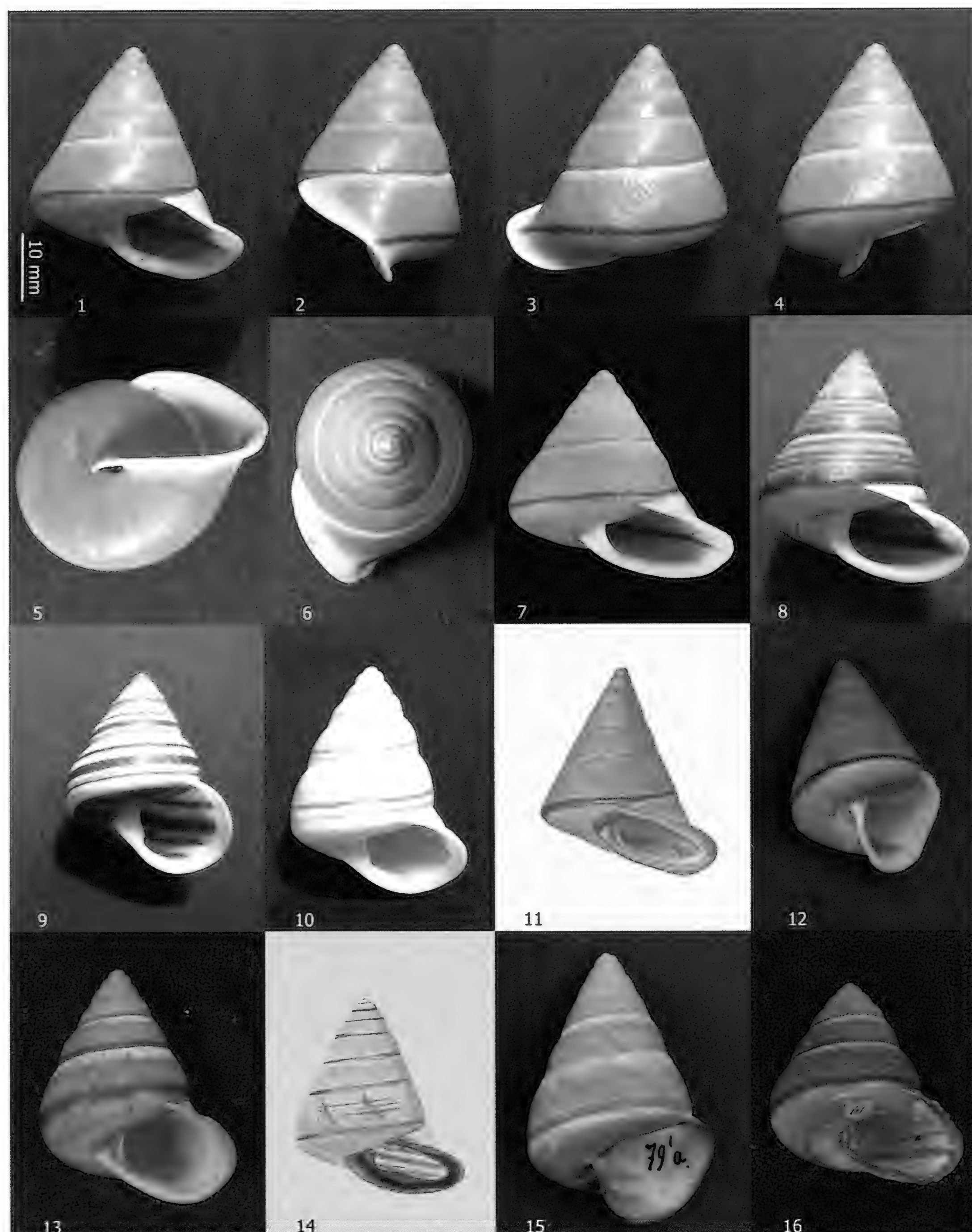


Plate 1. *Papuina abbasianus* n. sp. compared with relatives from the same region and the Aru Islands (images reflect natural shell size ratio). **First and second rows, *P. abbasianus* n. sp., Figures 1–6** Holotype, **Figure 7** paratype 1 and **Figure 8** paratype 2. **Third row, Figures 9–10** *P. pileus* Aru Islands (JP); **Figures 11–12** *P. astridae*, **Figure 12** Manokwari, Type, and **Figure 13** white-lipped var. *Wendesi* (Windesi), ZMA.MOLL.397489. **Fourth row, Figure 13** *P. euchroes* Indian Archipelago, Type ZMB.Mol.122101; **Figure 14** *P. lenta* locality unknown, Type; **Figure 15** *P. lenta* var. *pseudeuchroes* Fak-Fak, Type RMNH.MOL.287448; **Figure 16** *P. leucorhaphae* Karavafa River, Probable Type ZMB.Mol.51102. [Photographic credits: Figures 1–6 and 8–10 JP; Figure 7 Andy Tan; Figure 11 Adam and Leloup, 1939 Pl. 1, fig. 1; Figure 12 Biportal, 2019a; Figure 13 Museum für Naturkunde, 2019a; Figure 14 Pfeiffer, 1846 Pl. 40, Fig. 5; Figure 15 Biportal, 2019b; Figure 16 Museum für Naturkunde, 2019b].

Errata for *Amphidromus persimilis* Parsons, 2019.

Parsons, 2019. A new species of *Amphidromus* Albers, 1850 from Krong Pac District, Dak Lak Province in the Central Highlands, Vietnam. The Festivus 51(3):177-183.

Two errors were identified post-publication and are corrected as follows:

(1) On page 177 in the abstract section:

“This paper describes a new subspecies of *Amphidromus* Albers, 1850 ...”

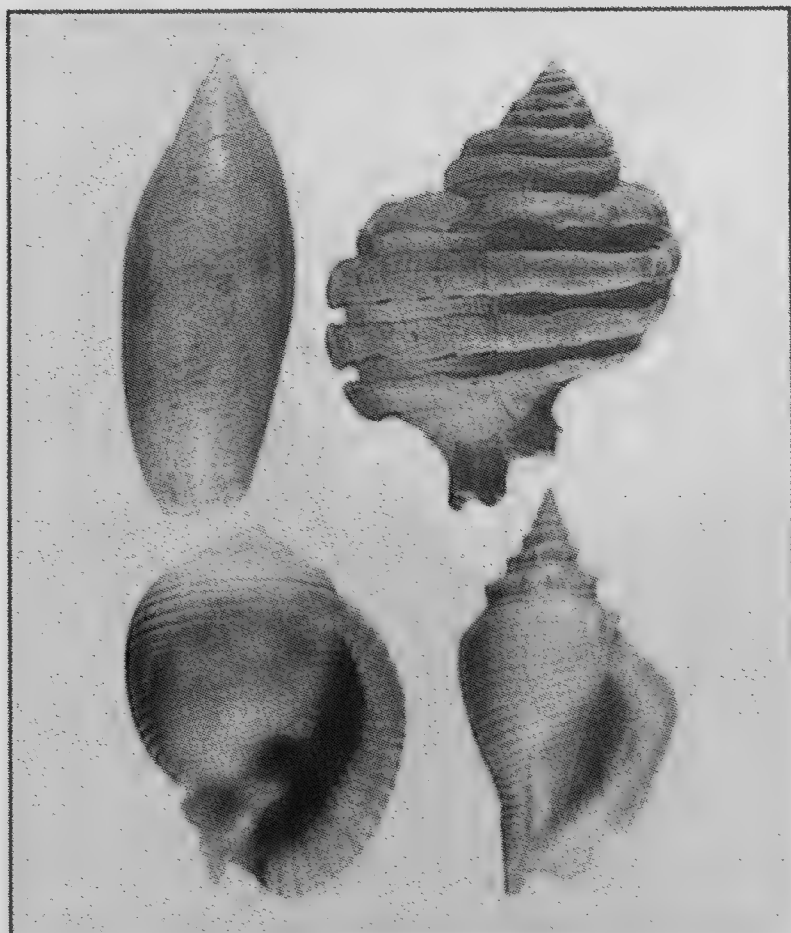
The phrase “new subspecies” should read as “new species”.

(2) On page 181 in the acknowledgments section:

“... I would like to thank Andy Tan of Malaysia for supplying the type specimens of the new subspecies” The phrase “new subspecies” should read as “new species”.

ATLAS OF FLORIDA FOSSIL SHELLS

(Pliocene and Pleistocene Marine Gastropods)



Edward J. Petuch, Ph.D.

Department of Geology, Florida Atlantic University

and

The Graves Museum
of Archaeology and Natural History

We have been lucky enough to acquire some *NEW* copies of this wonderful out-of-print reference. Get your copy of **Atlas of Florida Fossil Shells** - through either the San Diego Shell Club, Florida Seashells and Fossils, LLC (Melanie Briskin), or Conchbooks. Order your copy while supplies last.



Have a shell collection you would like to donate to The San Diego Shell Club?

The San Diego Shell Club is interested in your shell collection. As a 501c(3) organization, all donations to our Club may provide a tax write-off. When we receive a donation we provide a letter describing the items that may be used when filing your taxes.

While we cannot provide a value, donations of up to \$5,000 do not require a written appraisal. Since tax laws change regularly we recommend that you check with your tax accountant before relying on any information provided here.

We are interested in all types of shells, marine or land and all genera and species, including books on shells as well as items related to shells such as artwork, storage cases and tools. Your donated items will be used to generate income to support the Club's efforts in continuing Public education about shells and conservation of marine life throughout the world. If you would like to donate, please contact David Waller, SDSC Acquisition Chairperson, at dwaller@dbwipmg.com to schedule a time to discuss charitable gifting.

CLUB NEWS

2019 August - West Coast Shell Show

Our August event was our 4th annual West Coast Shell Show. See the article on page 323 for more details.

2019 September General Meeting

Our September general meeting was held on September 21, 2019, at Dung Vo's home in Costa Mesa. We had a good turn out with members from several counties present, and a wonderful spread of food and drink provided by members. Dung Vo gave a fascinating presentation on the Pleurotomariidae.

2019 October General Meeting

Our October general meeting was held on October 19, 2019, at Drs. Paul and Ann Tuskes' home in San Diego. We had a good turn out with members from several counties present, and a wonderful spread of food and drink provided by members. Paul Tuskes gave an interesting presentation on the Calliostomatidae of the Eastern Pacific.

Recognition of Responses to the article entitled “Beachcombing in Imperial Beach” by David B. Waller. The Festivus 51(3):247-255.

Thanks to Charles Powell for information indicating that two of the shells found on the beach are likely fossils. The small heavy bivalve (Figure 10 B) is *Here excavata*, a lucinid and is likely a fossil occurring in the San Diego Formation, an outcrop just offshore and to the north where wave action and/or longshore currents could easily deposit them in Imperial Beach, and the terebra-like shell (Figure 10 E) is probably a new species that Charles is describing from the San Diego Formation, or alternatively is a specimen of *Turritella gonostoma*. Charles also indicated that the mussel that the author noted was “similar to *Mytilus californianus*, Conrad, 1837 but has longitudinal ridges like *Septifer bifurcatus* (Conrad, 1837)” (Figure 10 D) is *Brachidontes adamsianus*, which occurs from the Southern California Bight south to Ecuador.

Thanks also to Will Ritter who helped identify the mussel as *Modiolus rectus* (Conrad, 1837) and its synonym *Mytilus flabellatus*, A.A. Gould, 1850 (Figure 10 A), from “Bivalve Seashells of Western North America,” Santa Barbara Museum of Natural History, 2000. The author is still looking for the identification of the shell depicted in Figure 10 C.



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2019 West Coast Shell Show

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This year's West Coast Shell Show was held in room 101 of the San Diego Botanic Garden Foundation building just west of the San Diego Natural History Museum in Balboa Park on August 24th and 25th. It was another fun and successful event for all those who attended; both adults and children alike. There were eight vendors offering shells for sale from all over the world, twenty exhibits on all types of shells to capture everyone's interest, two presentations on shells by notable speakers David Berschauer and David Waller, as well as a Club memorabilia table and lots of free shells for the children (Figure 3).



Figure 1. The WCSS Flier.



Figure 2. Phil Clover's table was popular with attendees.



Figure 3. Nancy Hale helping set up the Club table on Friday evening.



Figure 4. Dr. Wes Farmer setting up his table.

The exhibits included four displays by David Berschauer titled “Sibling Species and the Rise of the Isthmus of Panama,” “Caribbean Volutidae,” “Trophonidae of the World” and “Introduction to Shell Collecting” (Figure 5); four displays from Scott Zaragoza titled “Freshwater Shells of Africa,” “Explosion of Discovery,” “*Nautilus pompilius*” and “Kokopelli”; two displays from Roger Clark titled “The Genus *Melengena*” and the “New Buccinidae from the Aleutians”; two displays from Lisa Lindahl, one titled “Chambered Nautilus,” and the other wall art of an ocean scene in cast plaster; and one exhibit each from David Waller, titled “Beachcombing in Imperial Beach,” Robyn Waayers, titled “Limpets of the World,” Leo Kempczenski, titled “Cowries of the Genus *Leporicypraea*,” Dung Vo, titled “*Donax californicus*,” Bill Schramm, titled “Worldwide Cones,” Rick Negus, titled “Hawaiian Cypraea” and Pete Brimlow entering an ocean scene embroidered on a denim jacket. The highlights were: Robyn Waayer’s absolutely breathtaking display of limpets - a family of shells not often of interest to many collectors; Roger Clark’s display of new Buccinidae from the Aleutians that he will be naming shortly; Scott Zaragosa’s amazingly colored and beautiful land snails; and David Berschauer’s comparison of species appearing on both sides of the isthmus of Panama showing evolutionary differences that have resulted after this land formation arose and created a barrier between the Pacific Ocean and the Gulf of Mexico.



Figure 5. Exhibit by David Berschauer, Introduction to Shell Collecting - COA Trophy winner.

The presentations highlighted two of the exhibits: “Caribbean Volutidae” by David Berschauer focusing on research he conducted reviewing the *Voluta polypleura* - *demarcoi* complex; and “Beachcombing in Imperial Beach” by David Waller, which included a story of collecting shells on a local beach and using the Sea Shells of Southern California (published by the San Diego Shell Club in 2018) as a guide for identifying those specimens. The presentations covered all levels of interest from scientific to general shell collecting.

Some of our big award winners were: Shell of the Show (any manner, Figure 6) for *Scaphella junonia curryi* to David Berschauer; Shell of the Show (self-collected, Figure 7) to Roger Clark for a new species of *Buccinidae*; and The Wes Farmer Educational Award went to Robyn Waayers for her fantastic display of limpets from around the world (Figure 8).

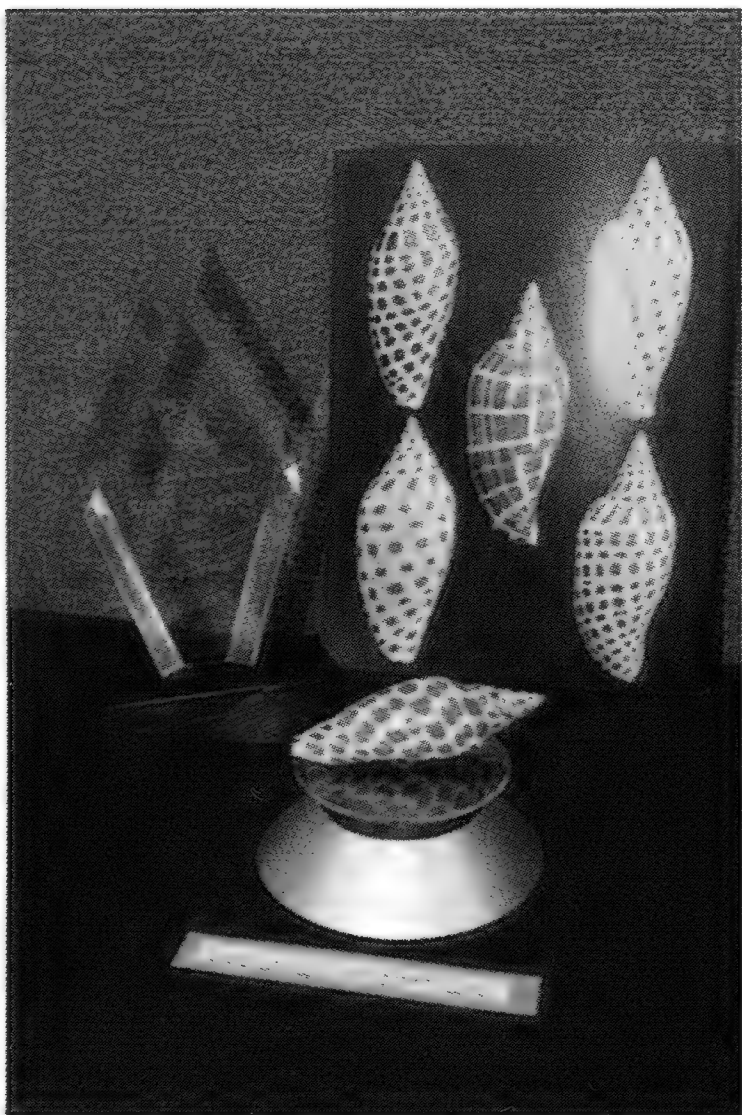


Figure 6. Shell of the show any manner to David Berschauer for *Scaphella junonia curryi*



Figure 7. Shell of the show self-collected to Roger Clark for *Buccinum sp* undescribed.



Figure 8. The Wes Farmer Educational Award for a limpet exhibit by Robyn Waayers. Quite impressive!

The vendors included, Dr. Charles Hames (Figures 10-11), Phil Clover (Figure 2), Dr. Wes Farmer (Figure 4), Rob Martinsen (Figure 12), Lisa Lindahl (Figure 13), Irene Wetsman (Figure 13), Rick Negus (Figures 9 & 13) and Roger Clark. Unfortunately, the author does not have an image of Roger's shells. However, we all look forward to seeing what Roger brings to the show.



Figure 9. Shells offered by Rick Negus



Figure 10. Shells offered by Dr. Charles Hames.



Figure 11. Dr. Charles Hames at his vendor's tables. The Cargiles talking with Rick Negus can be seen to Charles right in the background and Peggy Desanto, David Berschauer and Leo Kempczanski talking with Rob Martinsen to Charles' left in the background.



Everyone had a wonderful time, and I can't wait for next year's event. The 2020 WCSS will be held on August 29th-30th in room 101 of the San Diego Botanic Garden Foundation building just west of the San Diego Natural History Museum in Balboa Park. We are already making preparations and look forward to seeing you there.



Get your copy of **Sea Shells of Southern California** - exclusively through the San Diego Shell Club. \$30 plus tax

Ficidae - the Fig shells

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I was asked to do a presentation at one of our Club's general meetings earlier this year, and decided to pick a lesser known gastropod family that intrigued me - the Ficidae. I have always found these fragile thin shelled snails to be both odd and interesting because they are presumably carnivores and have a large aperture and a long siphonal canal. They were previously placed in the Tonnoidea along with the Cassidae (helmet shells), and anecdotal evidence was that they ate sea urchins and other echinoderms like their cousins the Cassids. The animal has a large angular foot, no operculum, a large head, two long tentacles, and a very long proboscis. Ficidae are found in relatively shallow to moderately deep water in sandy habitats of tropical and subtropical regions. There has been only one published study on these snail suggesting their feeding habits, which surprisingly showed cuticles and spicules in their guts - suggesting that they were feeding on worms and sponges. (Neo, M.K. 2010. The Taxonomic Status of Fig Shells with Notes on *Ficus variegata* (Röding, 1798) (Mollusca: Gastropoda: Ficoidea: Ficidae). Nature in Singapore 3:117-123.) More likely than not, these neogastropod snails are opportunistic carnivores and eat pretty much anything that they come across including worms, ascidians, sponges, sea cucumbers, detritus including dead fish, as well as clams and other gastropods that they can overpower with their large muscular foot (similar to Busyconids).

There are only fourteen named species in the Ficidae, which makes them a particularly easy group to collect and study. I acquired a sizable number of specimens at one of our Club's recent auctions. When I added those shells to what I already had and pulled my shells together to make a display for the presentation, I was surprised to learn that I had twelve of the fourteen species. Additionally, a decent collection of a lesser known family like this can make for an interesting and educational display for shell shows. Illustrations of specimens of all fourteen of the known Ficidae species are arranged on two plates at the end of this article (images not to scale). A detailed species list follows:

- Ficus dandrimonti* Lorenz, 2012. Mauritius. 30-70 mm. (Plate 2D)
- Ficus eospila* (Péron & Lesueur, 1807). Australia. 30-79 mm. (Plate 2G)
- Ficus ficus* (Linnaeus, 1758). SE Africa - W. Pacific. 40-165 mm. (Plate 2A)
- Ficus filosa* (Sowerby, 1897). Japan - Australia. 47-120 mm. (Plate 2C)
- Ficus gracilis* (Sowerby, 1828). Africa - Japan. 80-181 mm. (Plate 2B)
- Ficus investigatoris* (E.A. Smith, 1906). Somalia - Bay of Bengal. 85-130 mm. (Plate 1G)
- Ficus papyratia* (Say, 1822). N. Carolina - Gulf of Mexico. 60-165 mm. (Plate 1A)
- Ficus carolae* Clench, 1945. Florida Keys - N. Cuba across to Yucatan. 60-145 mm. (Plate 1B)
- Ficus lindae* Petuch, 1998. Colombia - Gulf of Venezuela. 60-120 mm. (Plate 1C)
- Ficus villai* Petuch, 1998. Honduras - Nicaragua. 60-94 mm. (Plate 1E)
- Ficus pellucida* Deshayes, 1856. Cuba - Bermuda. 28 - 70 mm. (syn. *F. howelli*) (Plate 1D)
- Ficus schneideri* Morrison, 2016. Kalbarri - W. Australia. 15-52 mm. (Plate 2E)
- Ficus variegata* (Röding, 1798). Arabia - Japan. 45-120 mm. (Plate 2F)
- Ficus ventricosa* (Sowerby, 1825). Sea of Cortez, Mexico to Peru. 70-150 mm. (Plate 1F)

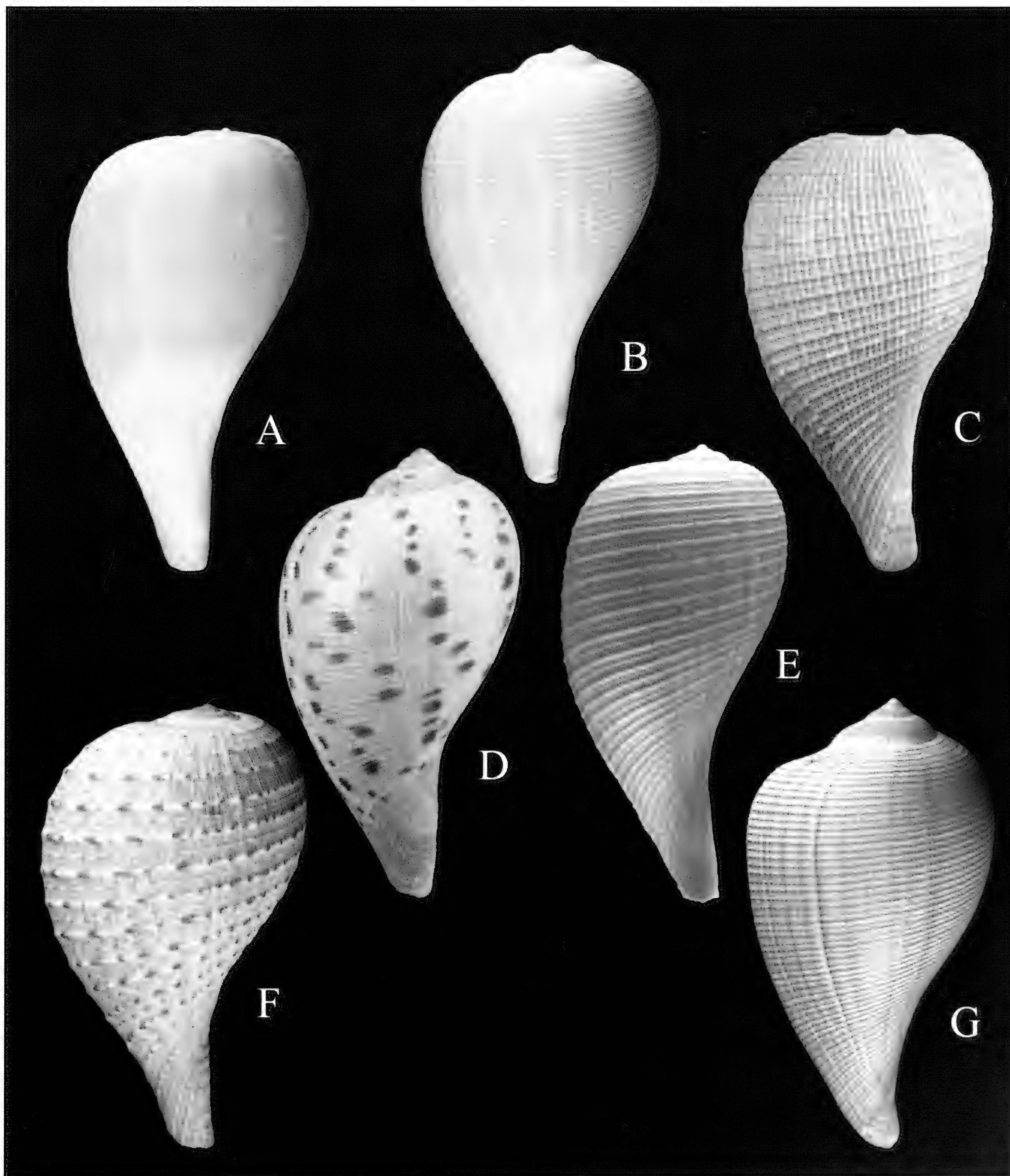


Plate 1. Ficadae species. A = *Ficus papyratia*; B = *F. carolae*; C = *F. lindae*; D = *F. pellucida*; E = *F. villai* (specimen in the E.J. Petuch collection); F = *F. ventricosa*; G = *F. investigatoris*. (Images not to scale).

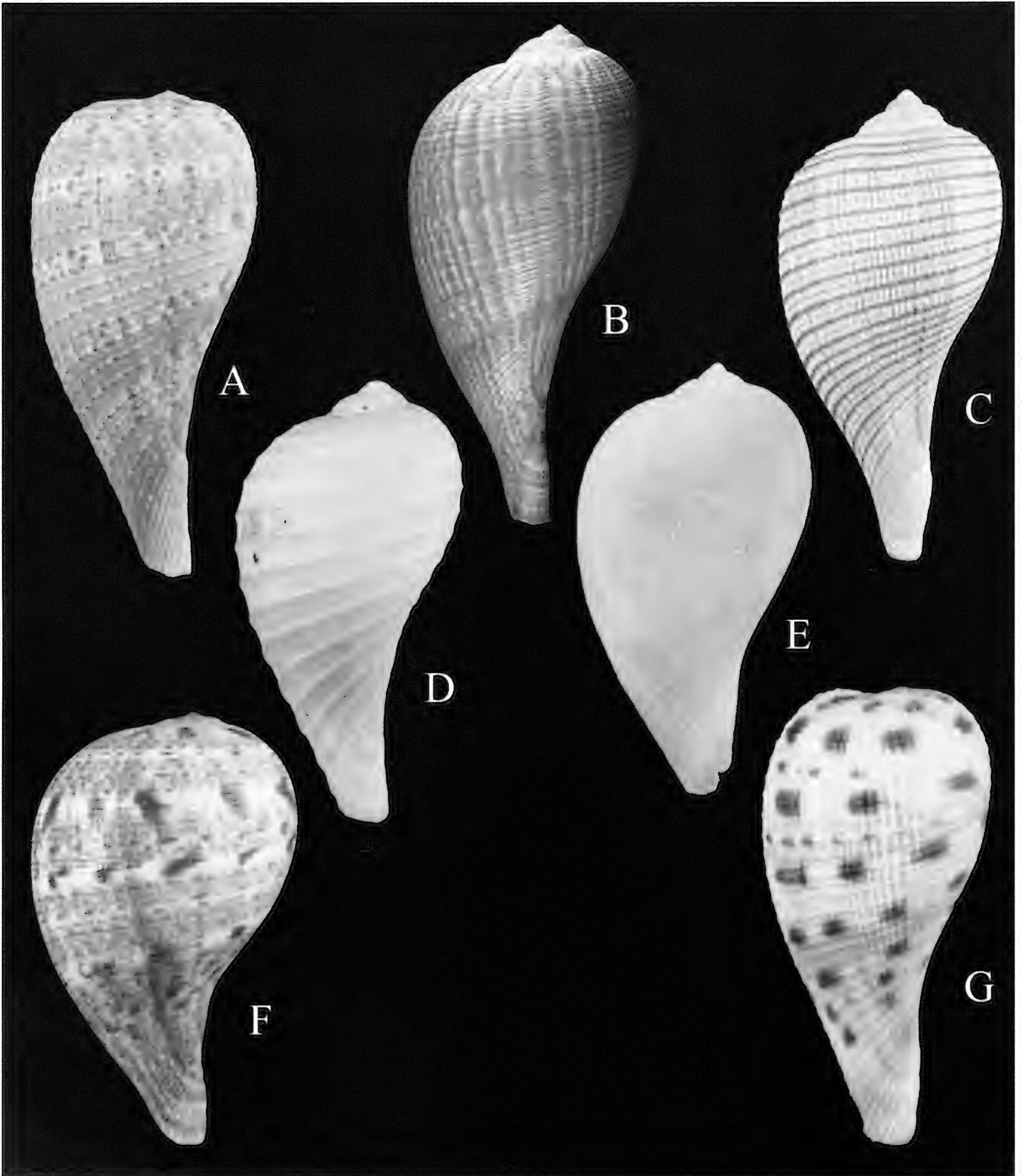


Plate 2. Ficidae species. A = *F. ficus*; B = *F. gracilis*; C = *F. filosa*; D = *F. dandrimonti*; E = *F. schneideri* (holotype is figured); F = *F. variegata*; G = *F. eospila*. (Images not to scale).

Scuba Diving off Imperial Beach: Sea Slugs and Kelp Beds

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Several recent general interest articles in *The Festivus* have highlighted shell collecting along the beach south of beautiful Imperial Beach. My home town! Both papers report on beach finds along the coast between the southernmost parking area on Seacoast Drive and south towards the Tijuana River mouth. David Waller (2019) described the collecting area. He reported that he found 93 species of shelled molluscs March 2019. Robyn Waayers (2014) found and illustrated *Turbonilla macouni* Dall & Bartsch, 1910. She also reported finding specimens of the scaphopod *Antalis pretiosum* (G. B. Sowerby II, 1860). This shell is well known in ethnomalacology studies, having been collected by indigenous peoples from deep water around Vancouver Island and elsewhere in the American Pacific Northwest. It was used for making jewelry and in ornamental trade with other native nations (Barton, 1994).

These beachcombing articles jogged my memory. I had made a scuba dive off Imperial Beach years ago and remember spotting the nudibranch *Baptodoris mimetica* Gosliner, 1991. But when and what else had I encountered? Searching several hundred pages of my dive logs, I found the records: not one, but three dives some 25 years ago.

25 September 1994, Dive Site A. Some years previously, I had met Ralph Evans at the Imperial Beach post office, and we often chatted about our sea adventures. He told me he had lost his fishing pole overboard the previous week, and wondered if I would go with him on his boat, and dive in search of it. Well, I know a needle in a haystack is easier to find than a pole in the ocean, but I had once found a friend's lost face mask in 60 feet of water off the Islas Todos Santos (Ensenada, Baja California), so maybe this would further enhance my search-and-recovery reputation. We launched his boat out of the Chula Vista "J" Street dock, went north through San Diego Bay, helped some stranded fishermen in front of North Island (really a peninsula, but that's what they call the Navy Base), then continued on past Zuniga Jetty, and south to Imperial Beach. After anchoring in the kelp beds, he acknowledged that we might not be anywhere near the loss site. He gave our latitude and longitude as 32° 37.4' N; 117° 08.8' W. My buddy diver Suzanne O'Bourke and I suited up. Long rollers were lifting the boat up and down, and underwater the surge pushed us back and forth.

The flat bottom was covered with loose cobble-stone rocks, all smoothed and eroded by the sea's movements. The depth range was a narrow 21-25 feet. The first rock I rolled yielded a bright orange-red and white *Limacia cf. mcdonaldi* nudibranch! Algal growth varied from incipient to longer, surface-reaching *Macrocystis* fronds. The invertebrates were the typical rocky, subtidal southern California denizens: shrimps, decorator crabs and other crustacea; erect bryozoans; small, dirty-cream colored *Lytechinus pictus* (Verrill, 1867) urchins; *Anthopleura* anemones; little chitons galore; and *Megastraea undosa* (Wood, 1828), *Californiconus californicus* (Reeve, 1844), and other snails.

On this dive, I observed five species of heterobranchs (Table 1, Site A), but no fishing pole.

13 November 1994, Dive Site B. My colleague and friend, fellow marine biologist Ron McPeak had phoned me a few days earlier, saying that he had to do a quick photographic survey of the Imperial Beach kelp beds for an upcoming Kelco meeting, and he asked me to join him. Ron was one of Kelco's scientific field researchers.

Economic and ecological interests have stimulated research about the kelp beds. Southern California's giant kelp (*Macrocystis pyrifera*) can grow up to two feet a day under the best conditions, producing a new canopy two or three times a year. Like lawn mowers, the Kelco harvesting boats sheared off the plant blades within a few feet of the surface. Kelp harvesting off California began just prior to World War I, as an alternative potash source (used in explosives and fertilizer) to that supplied by Germany. After the war demand for potash fell, and commercial kelp harvesting came to a rather abrupt end. In 1929, Kelco was founded to harvest kelp and extract the polysaccharide algin from its cell walls. Algin forms a gooey gum when chemically hydrated, and its colloidal properties make it useful in a variety of products, including candies, ice cream, gelatins, and peel-off facial masks.

Kelp forests form dynamic ecosystems, and thousands of organisms are dependent upon this biohabitat. Their locations and size vary yearly. The Imperial Beach kelp bed, always smaller than the Point Loma forest, only reached harvestable size in 1987, in the 57th year of Kelco's history as a company.

Macrocystis forests are subject to natural and anthropogenic disturbances and threats. Often there is a cascade of events that interact sequentially to damage the kelp. Severe winter storms can batter the canopies and dislodge the plants. El Niño conditions destroy the plants, probably because the warm water encourages the growth of phytoplankton that consumes the nutrients in the water upon which the kelp is dependent. Sewage outflow into the Los Angeles and San Diego kelp beds caused major deterioration in the mid-1950s. The human-caused disappearance of natural sea urchin predators (*e.g.*, the extinction of sea otters and the overharvesting of sheephead fish and lobster) allowed the urchins to proliferate into algal-consuming hordes. The kelp curler *Sunamphitoe humeralis* (Stimpson, 1864) is a well-known kelp feeder. This gammarid amphipod forms a familial nest by bending over an edge of the blade and securing it with mucus. Its abundance is normally controlled by a natural predator, the surfperch. However, when the canopy disappears, the predator's population can precipitously decline, resulting in an explosion of the kelp cutters and the "curling" and death of 50% of the kelp plant's blades.

The literature on *Macrocystis* physiology, ecology, and anything else interesting, is multitudinous. Wheeler North's (1971) massive volume is a dated, but good starting point; especially relevant for this tale is the San Diego Reader article by Jeannette DeWyze (1987). She describes Kelco's work and the important studies conducted out of Paul Dayton's Scripps Institution of Oceanography lab (see selections in the References / Additional Reading).

So as my buddy Tom Smith and I headed south out of Mission Bay on Ron McPeak's boat, I knew we would be diving in an interesting area. We anchored south of the pier, at 32° 33' 58" N; 117° 09' 26" W. After gearing up we dropped into the 57° F water and followed the anchor line to the bottom, 47 feet deep. It was covered with small boulders, and in less than a minute I had spotted a *Felimida macfarlandi* (Cockerell, 1901) with its rich violet-colored body and two yellow dorsal stripes. Visibility was great - over 20 feet. We found a 19 cm sunflower seastar *Pycnopodia helianthoides* (Brandt, 1835), and numerous *Pachycerianthus fimbriatus* McMurrich, 1910, tube anemones. There was an abundance of *Balanophyllia elegans* Verrill, 1864, a reported prey item of the aeolid nudibranch *Phidiana hiltoni* (O'Donoghue, 1927) in southern Californian and northwestern Baja California (Bertsch & Aguilar Rosas, 2016).

We observed 10 species of slugs, 32 specimens of nudibranchs and 3 specimens of *Aplysia californica* Cooper, 1863 (Table 1, Site B).

13 November 1994, Dive Site C. Ron finished photographing the kelp, we pulled anchor, and headed inshore and to the north. Dropping overboard for our second dive of the day, Tom and I swam seaward, out past the kelp bed. The wind, surf and swells had picked up, so visibility had dropped to only about six feet, and we rolled back and forth with the water movements. Crawling over the small rollable rocks and boulders were lots of purple and red urchins, *Strongylocentrotus purpuratus* (Stimpson, 1857) and *Mesocentrotus franciscanus* (A. Agassiz, 1863). Again we found the stony coral *Balanophyllia* and another *Phidiana hiltoni*. We observed a number of *Leucilla nuttingi* (Urban, 1902) sponge clumps, and a single specimen of its predator *Aegires albopunctatus* MacFarland, 1905 (Bertsch, 1980), although the nudibranch was not feeding on nor associated with its prey.

A real highlight was finding four individuals of the fileclam *Limaria hemphilli* (Hertlein & Strong, 1946) under rocks in their nests. One was disturbed enough to swim through the water – a marvelous swooping up and around, flapping its valves together, with its tentacle tips flailing about in the water.

We observed 11 species of slugs (Table 1, Site C), 28 specimens of nudibranchs, one *Aplysia californica*, and four *Bulla gouldiana* Pilsbry, 1895. The *Bulla* was the only heterobranch also collected by Waller (2019). He found one shell intertidally; our subtidal animals were alive and crawling.

Of note is the rarely reported *Baptodoris mimetica*. It is a small yellowish dorid with white spots, and mimics the coloration of several *Doriopsilla* porostomes. However, as a member of the Discodorididae, it has a radula, quite different from the toothless Dendrodorididae! Field identification of *B. mimetica* was easily confirmed without dissection, by rolling the animal over and examining its buccal region. Distinct oral tentacles, lacking in *Doriopsilla*, were readily visible.

Dr. James H. McLean (1936-2016), former Curator of Malacology at the Los Angeles County Museum of Natural History, and recipient of the 2013 Festivus Award of the San Diego Shell Club, is well known for his detailed work on gastropod taxonomy (Groves, Geiger, Vendetti & Coan, 2019). However, his fourth published paper (McLean, 1962), was on kelp bed ecology, based on his

scuba diving research! Among the 204 invertebrate species he reported associated with the kelp beds off Carmel, California, he cited nine species of nudibranchs (for him a rare event, since they lack shells). Four of those species (although under different names) were found by me in my Imperial Beach dives: *P. nobilis*, *D. sandiegensis*, *F. macfarlandi* and *H. opalescens*.

Photographs of 16 heterobranch species and most of the invertebrates mentioned in this article are found in Bertsch & Aguilar Rosas, 2015. The two species not illustrated there, are shown here: *Baptodoris mimetica* (Figure 1) and *Cadlina flavomaculata* (Figure 2).

There is definitely more research that needs to be conducted in Imperial Beach, the newest “Shelling Capital of the World”!

SPECIES	SIZES (in mm)	NUMBERS	SITES
Cephalaspidea			
<i>Haminoea</i> sp.	Eggs only		A
<i>Bulla gouldiana</i> Pilsbry, 1895	28-38	4	C
<i>Navanax inermis</i> (Cooper, 1863)	11-38	9	A
Aplysiomorpha			
<i>Aplysia californica</i> Cooper, 1863	61-110	4	B, C
Nudibranchia			
<i>Acanthodoris lutea</i> MacFarland, 1925	15-33	6	B, C
<i>Aegires albopunctatus</i> MacFarland, 1905	6 & 7	2	C
<i>Limacia</i> cf. <i>mcdonaldi</i> Uribe <i>et al.</i> , 2017 ¹	8 & 9	2	A
<i>Baptodoris mimetica</i> Gosliner, 1991	17-18	3	B, C
<i>Diaulula sandiegensis</i> (Cooper, 1863)	15-34	6	B, C
<i>Geitodoris heathi</i> (MacFarland, 1905)	8-13	3	A
<i>Peltodoris nobilis</i> (MacFarland, 1905)	15 & 88	2	B, C
<i>Rostanga pulchra</i> (MacFarland, 1905)	14	1	C
<i>Cadlina flavomaculata</i> MacFarland, 1905	9	1	C
<i>Cadlina limbaughorum</i> Lance, 1962	23 & 27	2	B
<i>Felimida macfarlandi</i> (Cockerell, 1901)	11-16	3	B
<i>Doriopsilla</i> cf. <i>albopunctata</i> (Cooper, 1863) ²	8-37	46	A, B, C
<i>Hermisenda opalescens</i> (Cooper, 1863)	18	1	B
<i>Phidiana hiltoni</i> (O'Donoghue, 1927)	28 & 49	2	B, C

Table 1. Species of heterobranch gastropods observed off Imperial Beach. Sites are described in the text. Site A: 32° 37.4' N; 117° 08.8' W; water depth 21-25 feet. Site B: 32° 33' 58" N; 117° 09' 26" W; water depth 47 feet. Site C: A bit northeast of Site B, nearer the pier and shore; water depth 32 feet.

Recent taxonomic studies and DNA analyses have changed the species names from what I had originally identified them. Two are of note.

1. The two specimens of *Limacia* I originally identified as *Laila cockerelli*. Ortea *et al.*, 1989, synonymized *Laila* MacFarland, 1905, with *Limacia* Müller, 1781, and Uribe *et al.*, 2017, named a new species, *L. mcdonaldi*. This species and *L. cockerelli* are sympatric in California,

but *L. cockerelli* ranges north to Alaska from Point Loma, and *L. mcdonaldi* ranges from Salt Point, Sonoma County, south to Cabo Pulmo and into the Gulf of California to Bahía de los Ángeles (Bertsch, 2014). Since the Imperial Beach animals were found at the extreme southern end of the range of *L. cockerelli*, but well within the heart of *L. mcdonaldi*'s range, I've identified the animals as *L. cf. mcdonaldi*.

2. A similar situation occurs for the porostomes I observed. My field logs identified them as *Dendrodoris fulva* and *Doriopsilla albopunctata*. Porostomes that are yellow or yellowish orange to brown, with white dorsal spots from southern California and the Gulf of California are now known under five different species names (Hoover *et al.*, 2015). Based on geographic considerations, the most parsimonious name for the Imperial Beach animals would be *D. albopunctata*.

No photographs were taken during these dives, so any definitive identification is impossible. There are no range extensions involved under any of the species' names.

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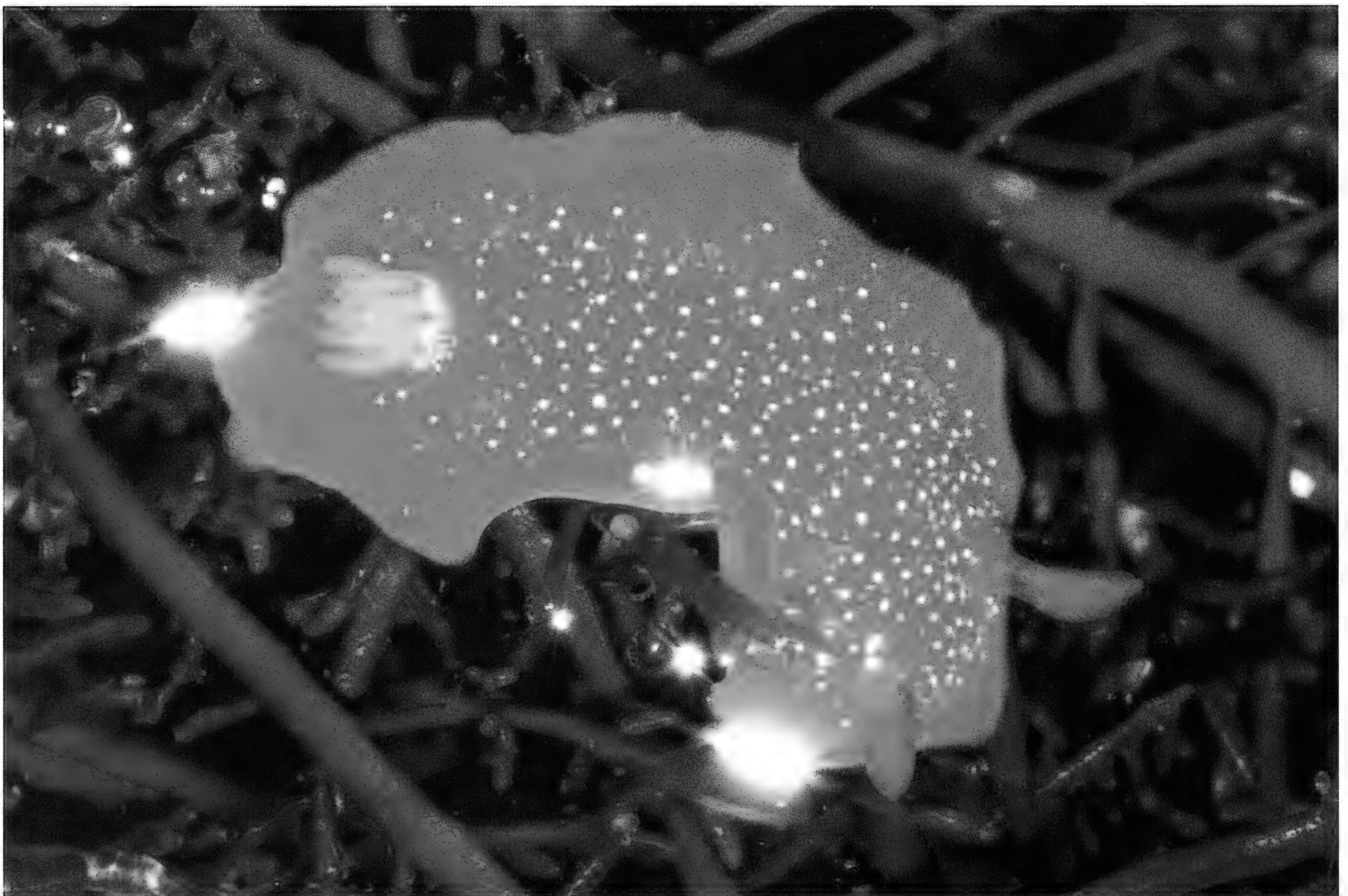


Figure 1. *Baptodoris mimetica*, 20 mm animal, intertidal, La Jolla, 14 June 2018. Photo by Craig Hoover.



Figure 2. *Cadlina flavomaculata*, 17 mm animal, 75 feet deep, off Point Loma, 5 January 1980. Photo by author.



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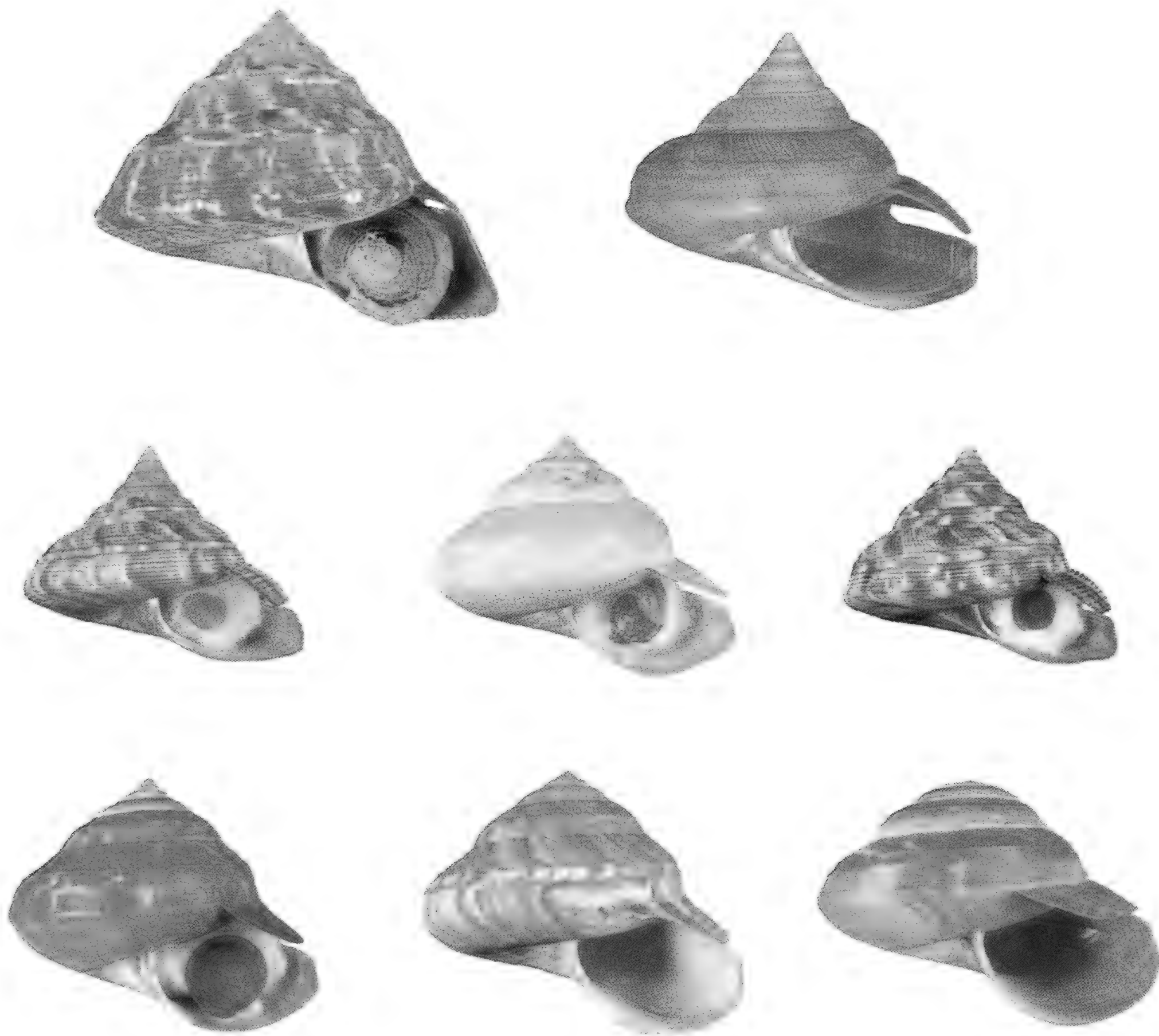
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E. adansonianus adansonianus (Crosse & Fischer, 1861), Bahamas, 106.1 mm. *B. poppei* (Anseeuw, 2003), Tonga Islands, 58.8 mm. *P. amabilis* f. *maureri* Harasewych & Askew, 1993, USA, 42 mm. *B. tangarana* (Bouchet & Métivier, 1982), New Zealand, 55.9 mm. *P. quoyanus* (Fischer & Bernardi, 1856), Curaçao, 50.7 mm. *B. philpoppei* Poppe, Anseeuw & Goto, 2006, Philippines, 65.1 mm. *B. charlestonensis* Askew, 1987, Martinique, 77.3 mm. *B. midas* (Bayer, 1965), Bahamas, 82.7 mm.

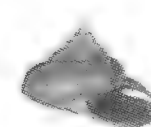
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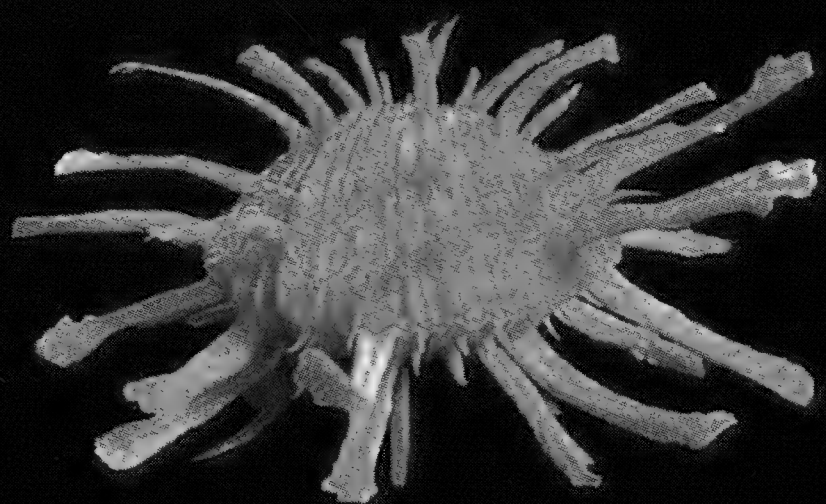
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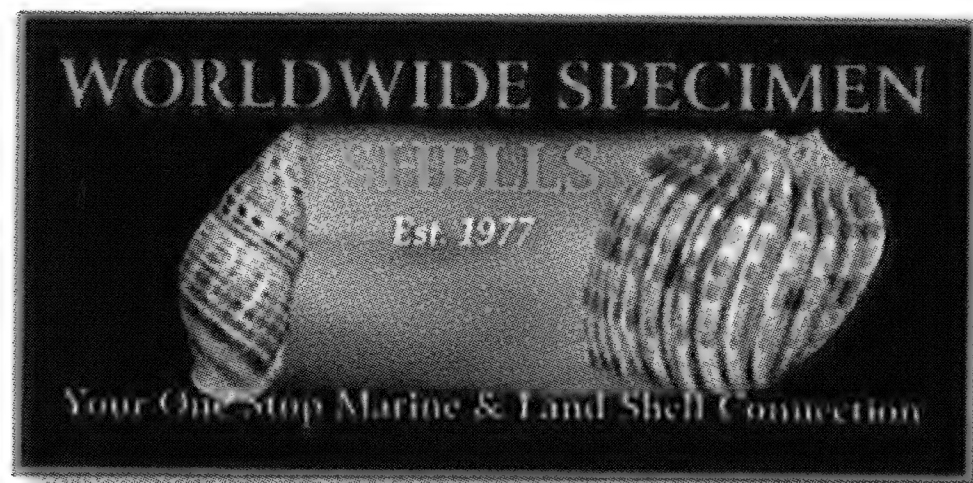
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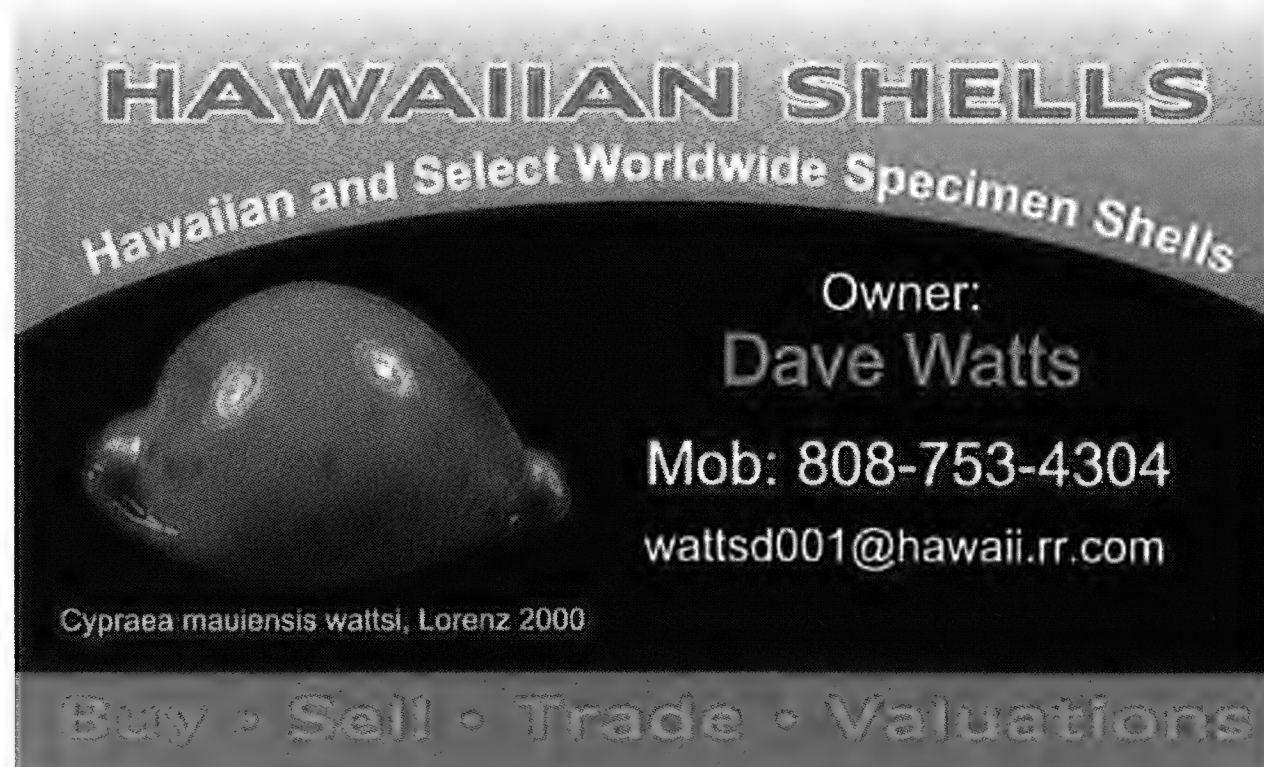
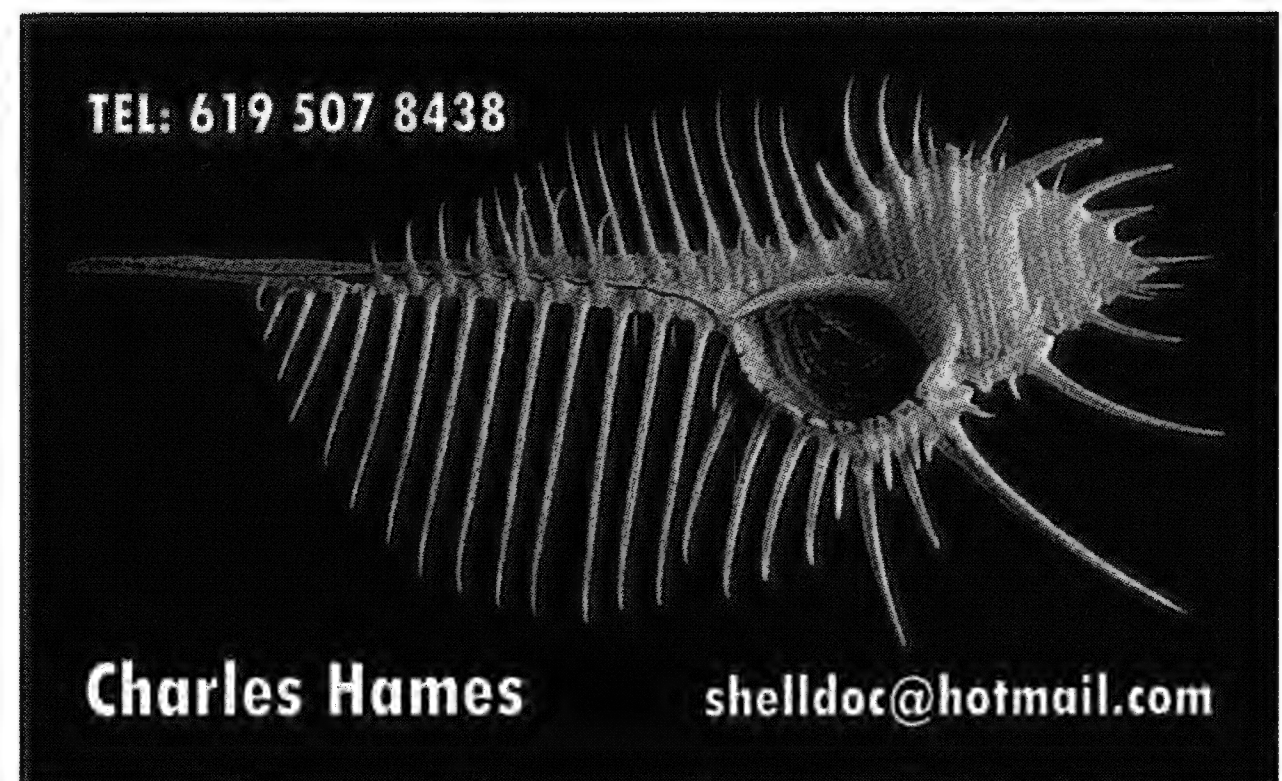


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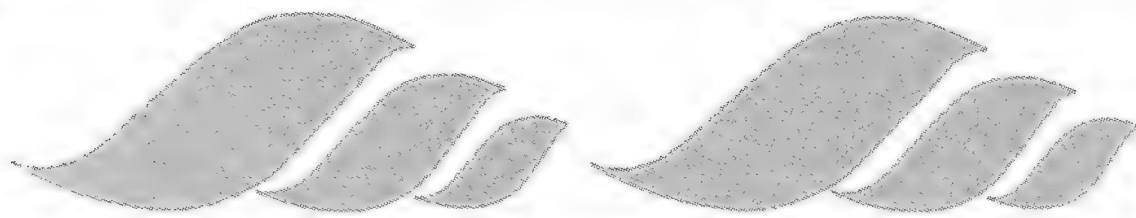
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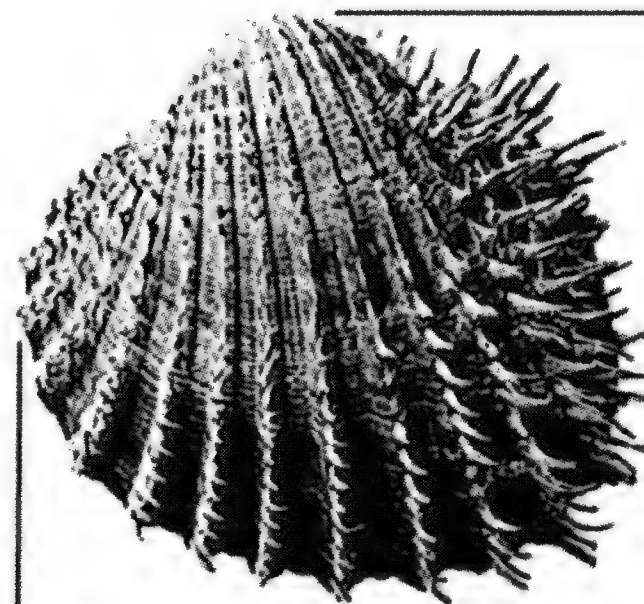
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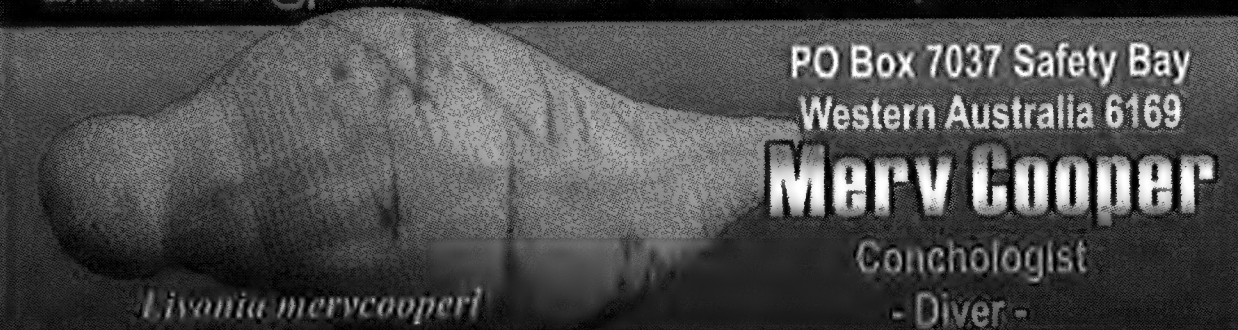
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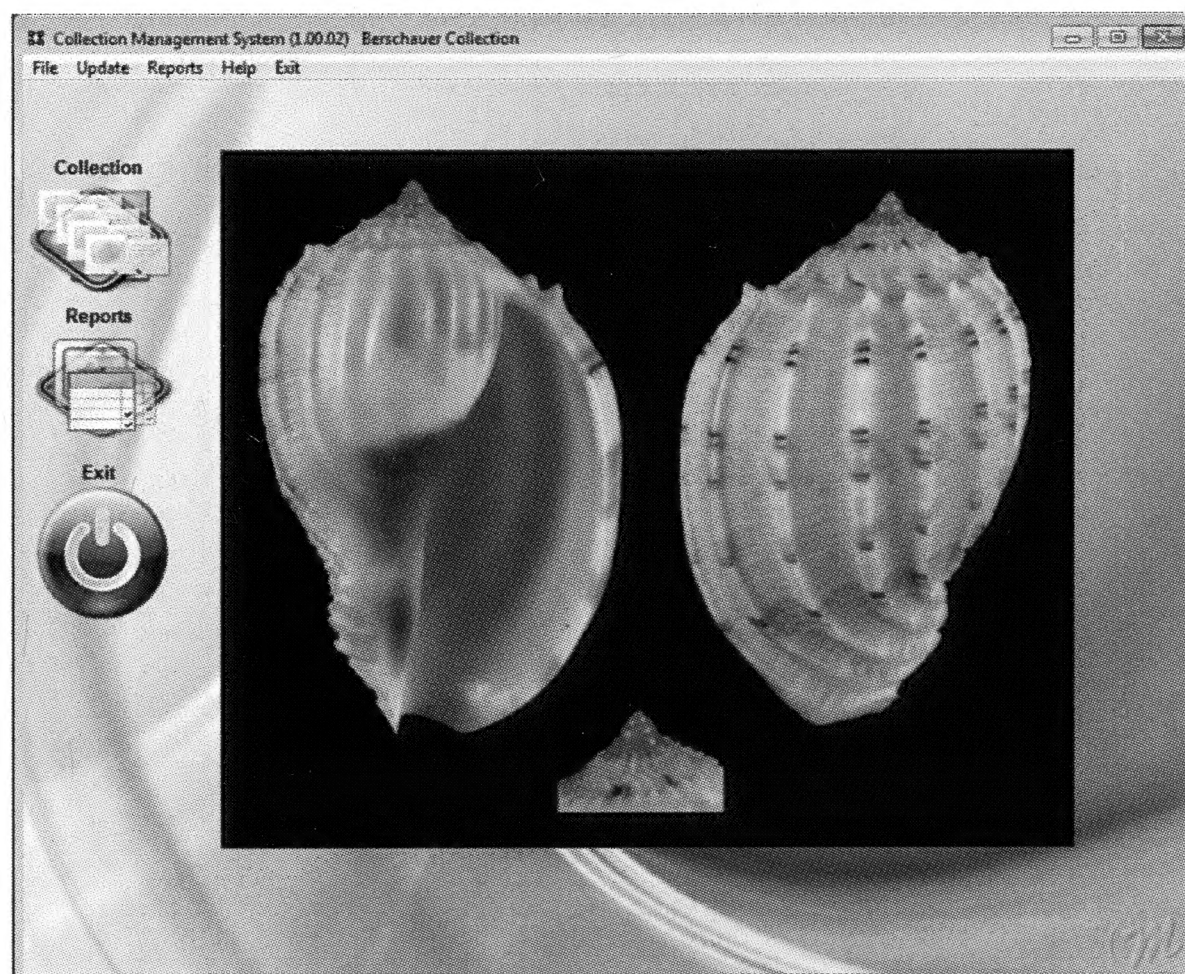


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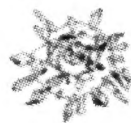


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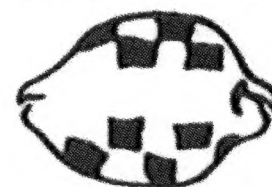
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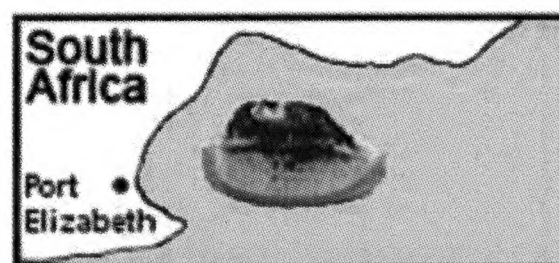
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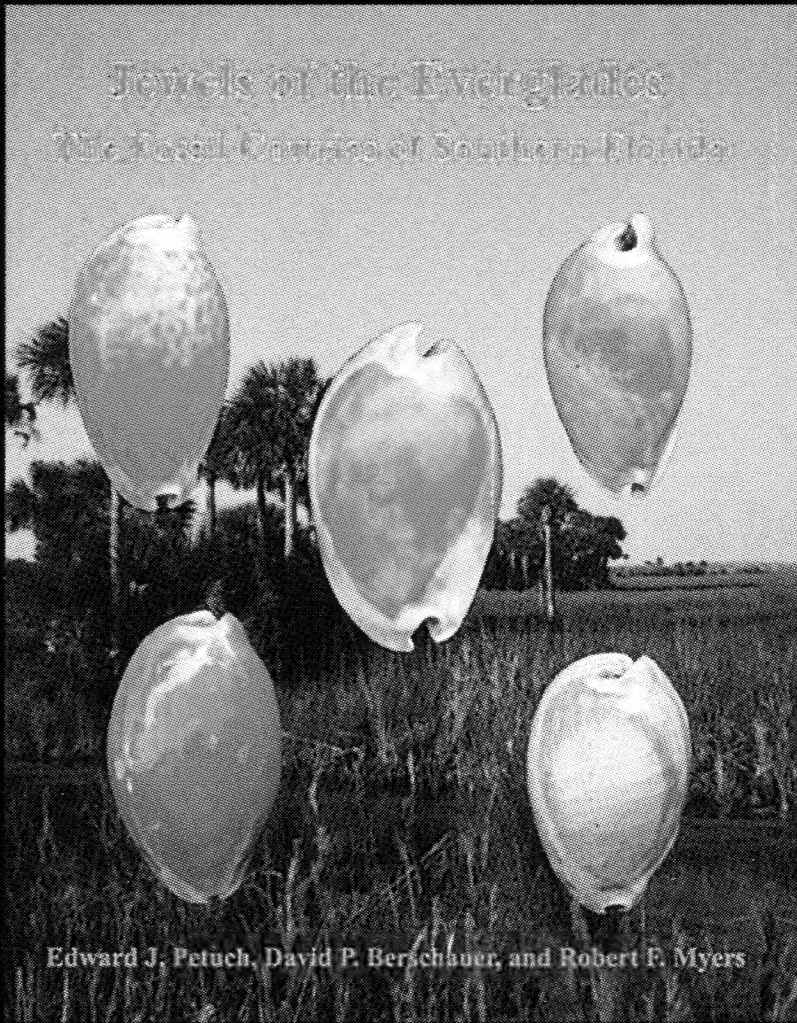
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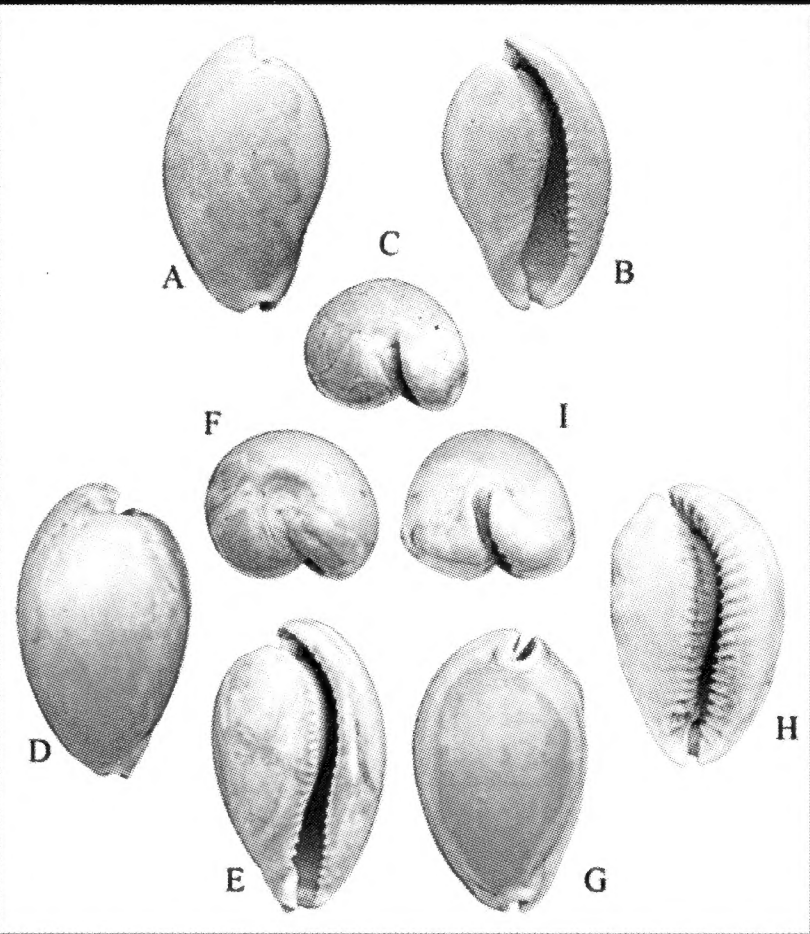
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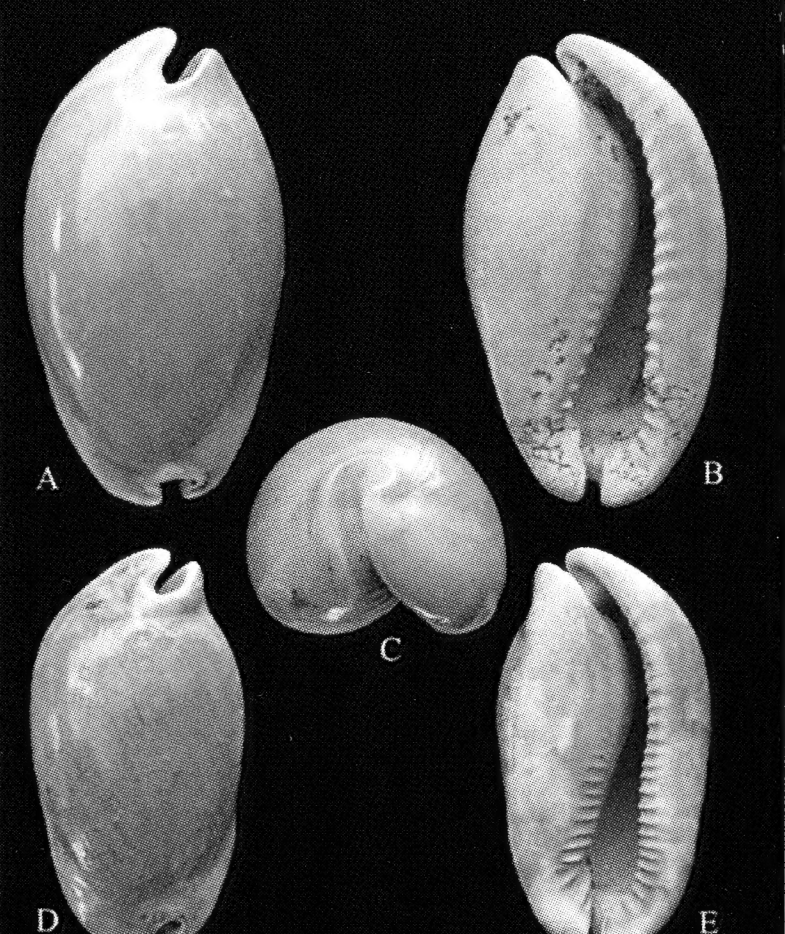
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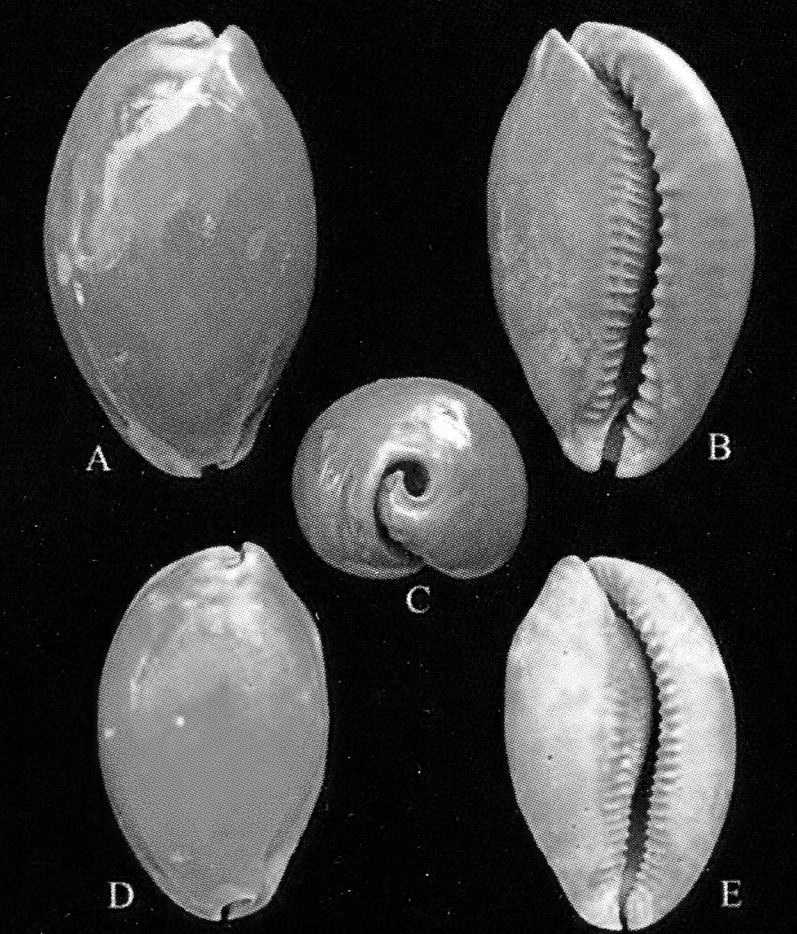
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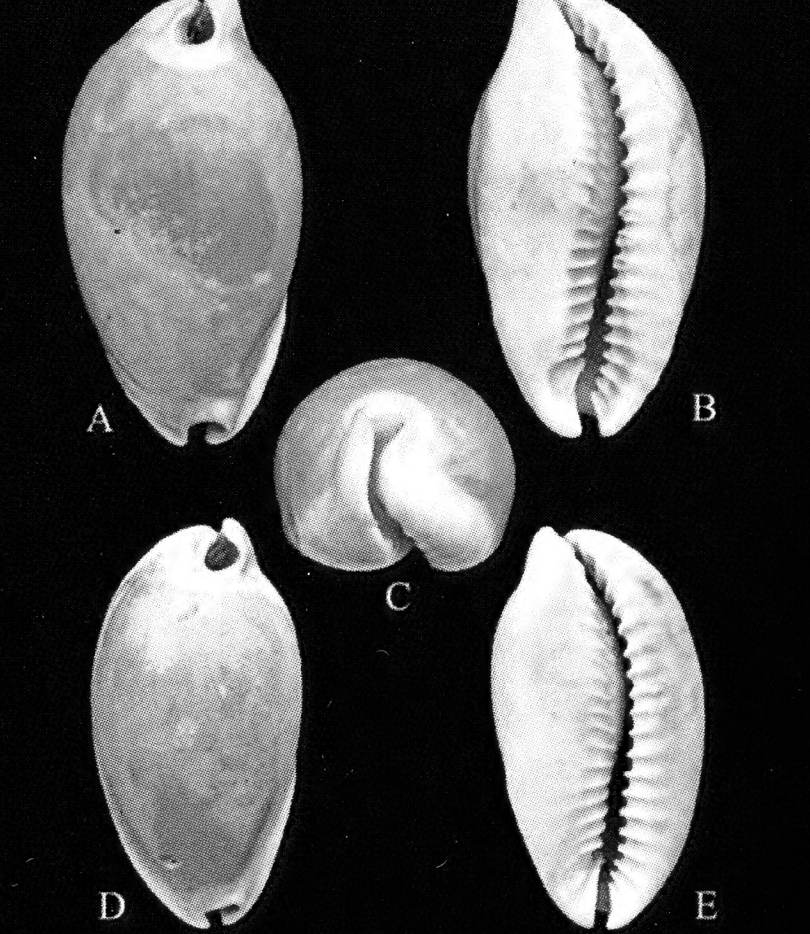


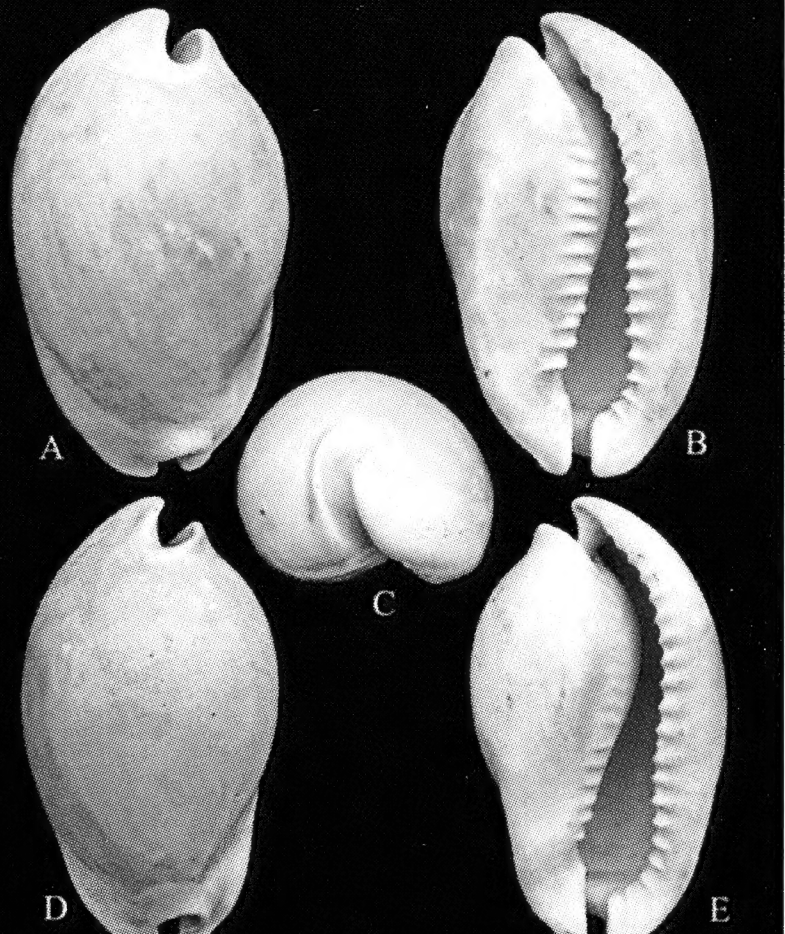
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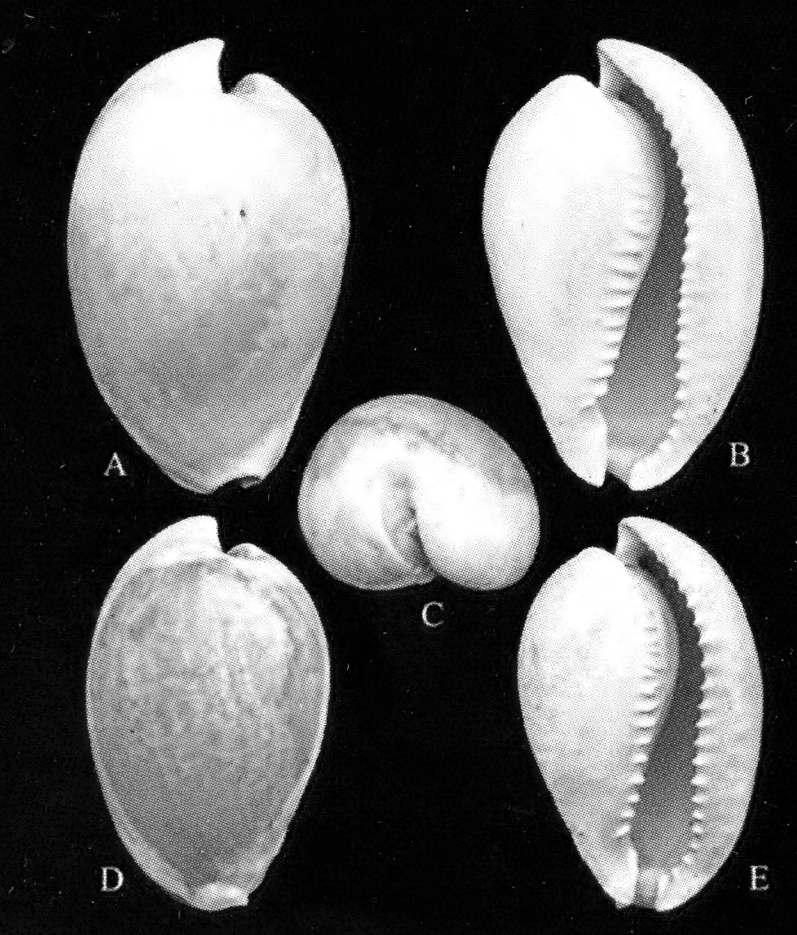


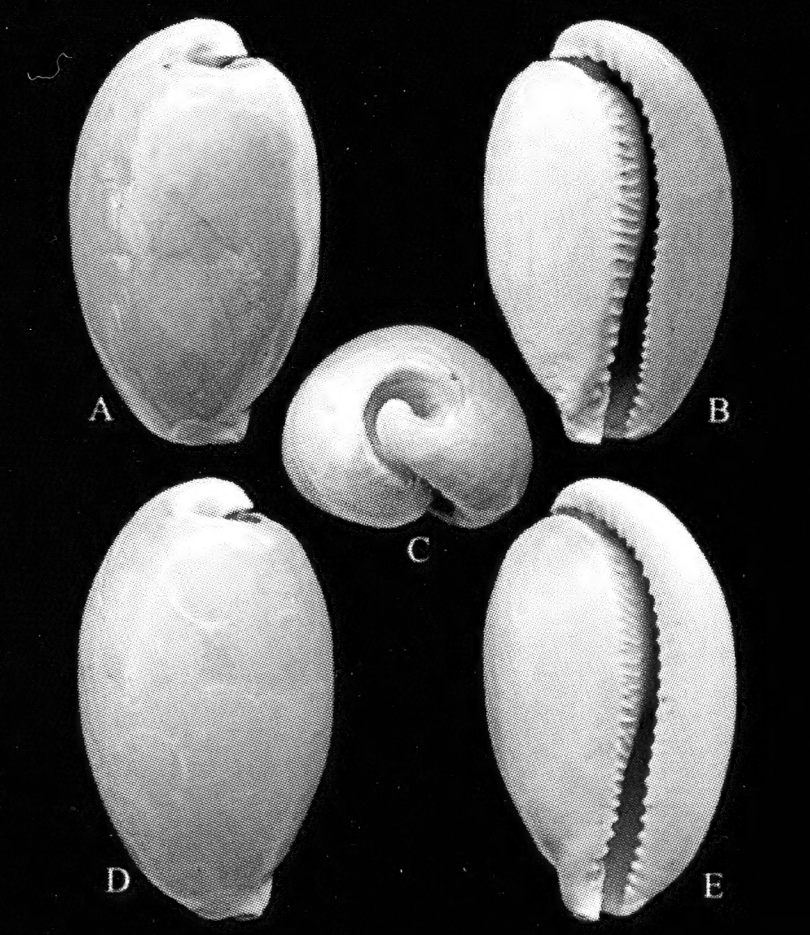


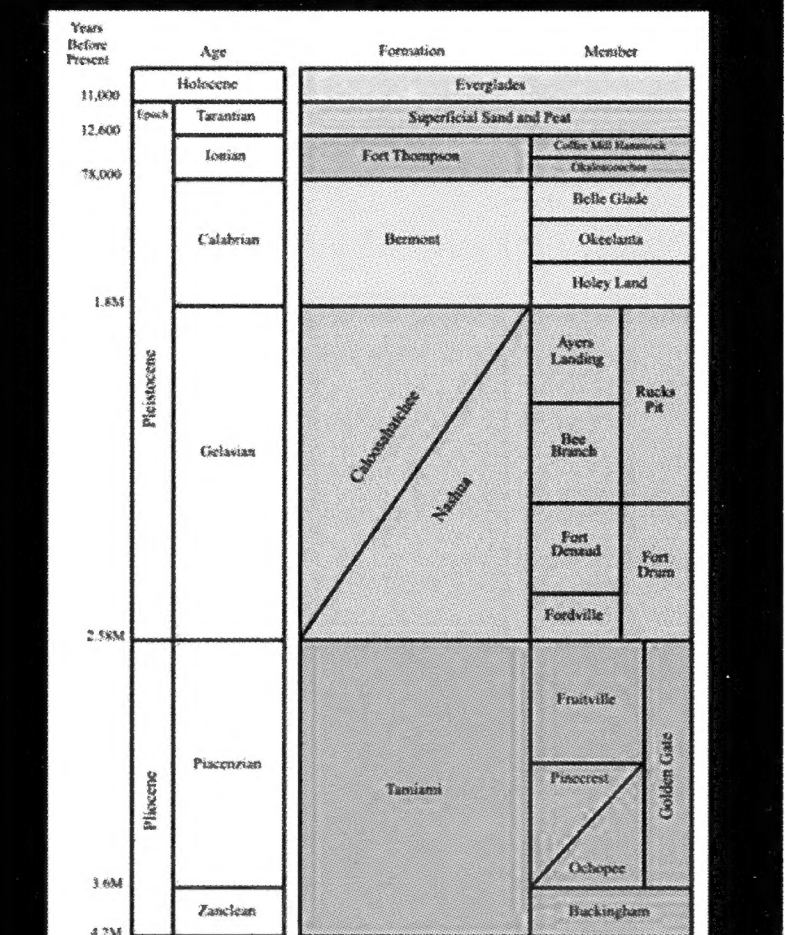






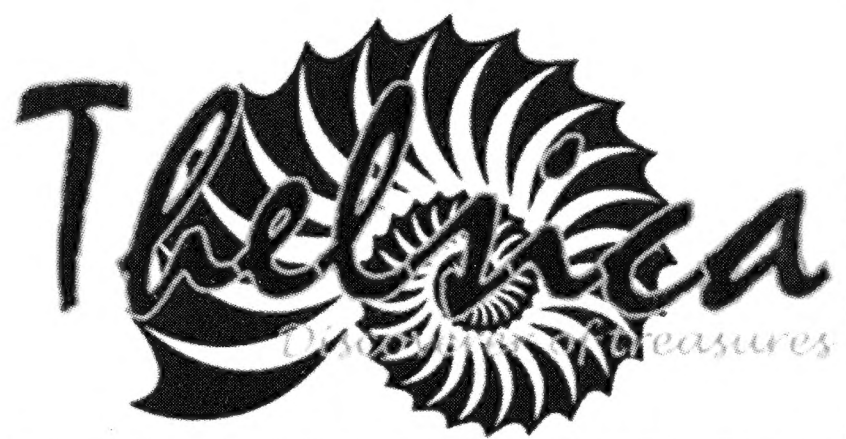







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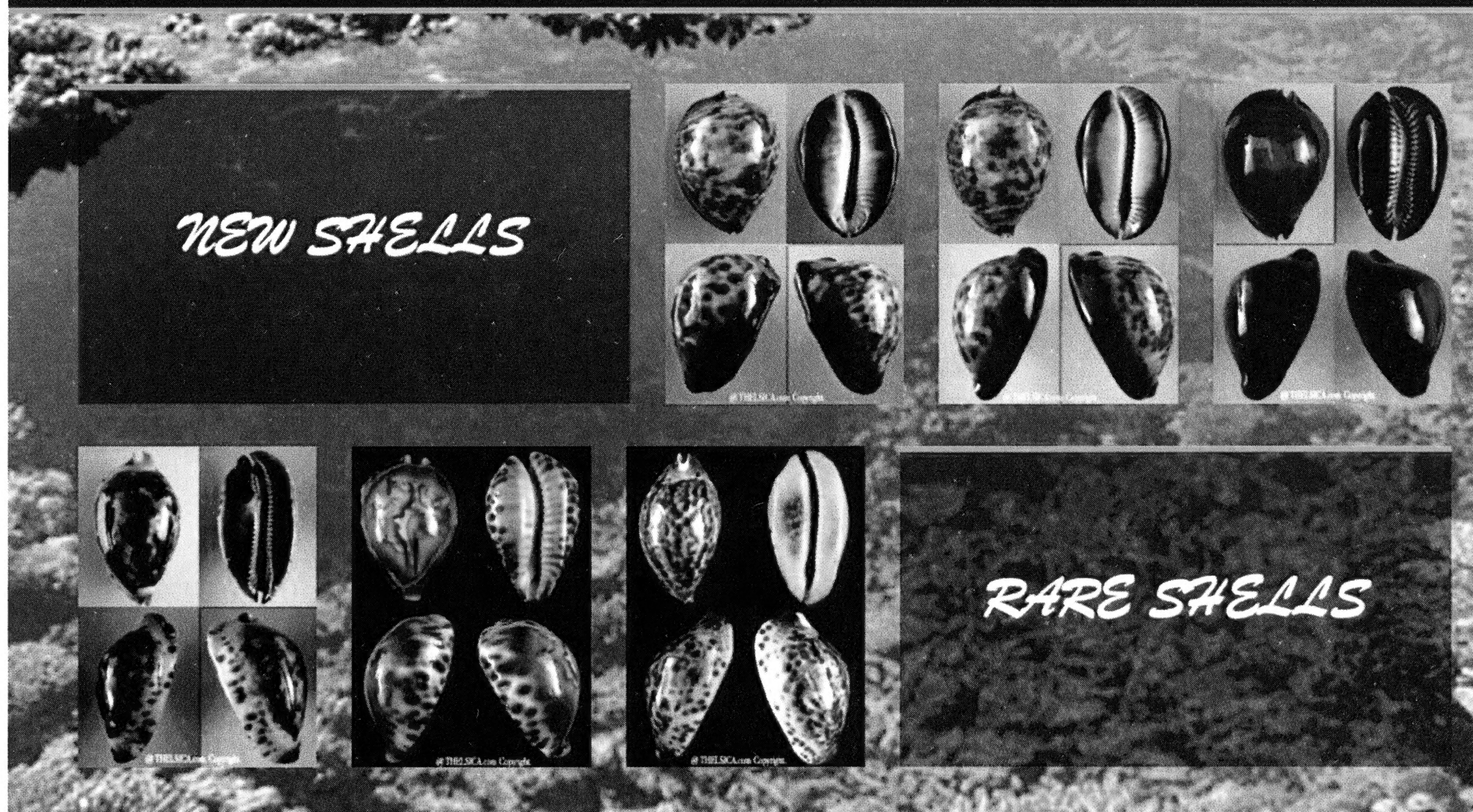
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